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THE ARTICULATION OF SCIENCE TEACHING IN THE HIGH SCHOOL WITH THAT IN THE GRADES.*

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The instruction that is given in science to-day in our grammar schools and in our high schools falls into two more or less distinct groups—nature-study in the lower grades, and formal or technical science in the secondary school. It does not require any very profound or close study of these two phases of science work to discover a wide differentiation in the methods, spirit, and purpose of the most advanced nature-study, and the usual high school curriculum. The facts of the case are that the so-called nature-study movement is a revolt from the older science instruction which had projected itself from the university into the secondary school, and from the secondary school into the lower grades. This radical departure from the academic method of giving science instruction has left a wide gulf between the work that the primary and grammar schools are endeavoring to do, and the usual science program of the secondary schools; and it is to the problem of better articulation of science teaching in passing from the grades into the high school that I invite your attention for a little while.

We all recognize that almost no attempt is being made to closely articulate science teaching in these two departments of our schools. Many science teachers are totally ignorant of the scope of the work and the methods employed in the grades below the high school. In many parts of the country little attention is given to science instruction, outside of geography and perhaps simple hygiene, before reaching the high school period. But in places where the attempt is made, under the inspiration of the

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new nature-study courses, we find a sudden break in the continuity of method and purpose in passing from the lower to the higher grades.

Unfortunately the period devoted to the education of our American youth has been broken up into more or less distinct units, each of these units being dominated to a large extent by the unit above in point of time. The curriculum of the secondary school has been greatly influenced by the demands made upon it by the college and university. Students must be equipped to enter these institutions of higher learning, and the educational efforts of the secondary school have centered about such lines of work as these institutions have required. Very naturally, of course, the spirit that has pervaded the high schools has worked its way downward into the intermediate and primary grades of our school system. As a direct result of such permeation of the influence of the university, school programs are still dominated by a vast amount of traditional matter. It is only within comparatively recent years that the individual to be educated has received any degree of consideration at the hands of educational philosophers. Under the older regime the content of knowledge was the chief consideration, and little regard was paid to the actual life needs of the individual receiving such knowledge, or to the mental operations whereby it might be acquired. Teachers were too busy developing subjects to pay much attention to the development of boys and girls. The end and aim has been to impart knowledge, and that of a distinctly academic sort, rather than the unfolding of the powers of the child.

Probably nowhere in the whole domain of educational endeavor is better opportunity offered for the rationalizing of educational matter and method than in the field of science. Scientific knowledge and appreciation is one of the very first elements of a modern liberal education, because it is that element that presents itself earliest to the senses of the child.

To postpone all science instruction to the high school period will mean to wait until the correct psychological moment for the presentation of much important matter has passed never to return. The child brings to the secondary school a large body of semi-scientific knowledge gathered from his experience both in school and out of school. The more closely this knowledge is related to the new matter that is to be presented to him, the more fruitful will be the results. The unity of science demands a close and

intimate relation between all parts of science instruction, whether it is given under the name of nature-study, art, geography, hygiene, biology, or physical science. If the very best science work is to be done, the high school and the grammar school cannot work as independent units, each totally ignoring the other. A crying need is the skillful adaptation, in the light of modern psychology, of both matter and method to the growing and unfolding mind of the child. Connect this with the task of relating the subject matter of the school curriculum to the present experience and future life activities of the student, and we stand face to face with the most important problem of twentieth century pedagogy. How important then is the work of those who shape the educational policy of our schools! Fine modern school buildings and splendid material equipment are of great importance in the training of the youth of our land, but of far greater importance is the adoption of proper courses of study and the training of capable teachers who can carry the work to successful completion.

Confining ourselves, however, to the field of science instruction, let us consider some of the possible means of affecting the more complete articulation of science teaching in making the transition from the grades to the high school. In the first place such organic unity will demand that present courses of study be considerably modified. Much of the traditional matter that has been inherited from times past, will have to be eliminated. Considerable vigorous pruning of the educational tree will be necessary.

Of course it is impossible for our curriculum to rise above our conception of the end and aim of education. In fact it furnishes us with a pretty definite and concrete notion of the scope and purpose of educational endeavor. Educators are not in perfect accord or agreement in their definition of education; but we find the fundamental notion of *adjustment* as a part of the general notion of education. It is the most rational fitting of the individual to the environment in which he must live and find his sphere of activity. This notion of education condemns educational uniformity and insists upon a different sort of training for different individuals, as well as for different communities.

Science instruction should be introduced at a very early period in the education of the child. There is no legitimate reason for postponing all science instruction to such a time that the great

masses who never enter the secondary schools are forever denied the privilege of pursuing it. This early introduction of science along with other great departments of knowledge, will necessarily mean that less attention shall be given to the three R's, while more attention shall be devoted to real things that enter into the life of the pupil and that will equip him for the most complete living. It must be fully appreciated that the three R's are simply the vehicles of learning and not learning itself.

After the first simple rudiments have been mastered, the further acquisition of skill in their use will be incidental to the knowledge getting process. The active process of learning to read and write, together with a fair knowledge of the fundamental principles of arithmetic, should be practically complete by the time the child has reached the age of ten. Even before this time they ought to drop somewhat into the background, giving place to the more distinctly educational subjects.

The early and successful introduction of science into the curriculum of the grammar school demands very careful selection of material and extreme wisdom in its presentation. To relate the so-called "dry bones" of science to the active and spontaneous interests of children is no small task. And this is just the point where many efforts to teach elementary science to young children have failed. Dr. C. F. Hodge says that the failure is probably due to lack of distinctions between the special and trivial in science, and the fundamental. Object-lessons have been discarded because their worth-whileness was too small. They dealt with the special and trivial and therefore found no permanent abiding place in elementary science instruction. Scientific analysis is a fundamental process, but it must give place to the study of the whole object in elementary instruction. The child is interested in the whole bird, the whole bug, the whole flower, and not in any microscopic analysis of its parts. Children can only see things in large masses, while more advanced pupils can examine the minutia of their subject. Professor James says that "the child before adolescence is most interested in things, things that move, living things, human actions, and accounts of human actions; while theoretic curiosity, curiosity about the rational relations between things, can hardly be said to awaken until adolescence begins."

It is commonly maintained that the child represents, more or less completely, in his mental and physical development, the his-

tory of the race. Hence a study of the development of man in his relation to nature will throw some light on the development of the child in his relation to the world about him. There can be no doubt at all but that man's first great fundamental relations to nature which opened the way to civilization, were essentially *biological*—the domestication of animals and the cultivation of plants. Primitive man knew almost nothing about the structural side of the plant or animal which he had made his servant. He simply knew the living organism as a unit, as a factor in his own welfare, as something which gave him additional prowess, and therefore enlisted his interest. Knowledge of the subtle forces of nature and of the laws which they obey, came to man at a comparatively recent date. The great field of scientific investigation and knowledge had to await the development of intellectual power that enabled him to receive it. Some such evolutionary process goes on in the development of every child. We thus have unquestioned evidence that the rational treatment of science as a subject of education, demands that the early instruction shall be mainly biological. A careful study of the awakening interests of children will dictate the time when the introduction of the more distinctly physical side of science instruction may profitably begin. Under the present prevailing arrangement in most schools, formal science teaching has an exact beginning, usually at the beginning of the high school course.

When the proper articulation is affected with the work of the lower grades, no exact time will be found when such formal or more or less technical instruction, may be said to begin. Change of method will be as gradual as the change in the tastes, habits, and mental horizon of the growing child.

It is to be regretted that in the past high school teachers have paid too little attention to what the grammar schools were endeavoring to do. They have been too busy with their own special subjects to give much attention to the work below the high school. The high school corps of teachers is usually recruited from among the annual crop of college and university graduates, and they bring with them university ideals and university standards. Instead of carefully studying the elementary schools from whence their students come, they allow the influence of the university to loom large upon their pedagogical horizon. So long as such a state of affairs persists, there can be little hope of any very close

organic unity between the science work of the high school and whatever may be attempted before reaching the high school.

It does not fall within the intended scope of this paper to suggest detailed courses of study or particular plans for the complete articulation of all grades of science instruction; but rather to offer general lines of action, under which the details of such a scheme might be worked out. Only experience and actual working conditions can finally determine the minutia of any plan, while the broader and more general principles are substantially the same for all sorts of conditions.

In the opinion of the writer an extension and enlargement of the most advanced notions of nature-study will doubtless be a move in the right direction. To be sure, as the case now stands, nature-study, in its spirit and purpose, is more or less at variance with technical science. This is not at all strange, but rather the thing to be expected; for nature-study is undoubtedly a revolt against the old time "science lessons" in the elementary schools. Of course formal science, having largely lost its prestige and power in this important field, naturally opposes the usurper.

Many of the teachers in the upper strata of science work say that they would rather that the students who come to them would have no science instruction at all, than to have them appear with an inaccurate and, as they maintain, poor equipment furnished by nature-study classes. But this failure is to be attributed, not to the general plan and purpose of nature-study, but rather to the lack of efficient teachers to carry out definite plans and to push forward the true spirit of the work. Those who malign the nature-study movement fail to understand the nature-study teacher's way of looking at things, and to appreciate the true nature-study spirit. Such adverse criticism comes, usually, from above where the academic idea prevails. But it must be remembered that the nature-study movement is the product of the common schools, and not of scientific investigators; hence the apathy, if not the open opposition of the specialist. But the leaven is gradually working its way upward, and we shall hope that eventually a better understanding and more friendly relations shall be established between the present contending forces.

Professor Wilbur S. Jackman, in a monograph on nature-study, read a couple of years ago before the National Society for the Scientific Study of Education, said: "The spirit of nature-study requires that the pupils be intelligently directed to the study

of their immediate environment in its relation to themselves; that there shall be, under the natural stimulus of a desire to know, a constant effort at a rational interpretation of the common things of life."

The spirit and purpose of nature-study appeal to us strongly because its working principles are so natural, so wholesome, and so free from limitations. It stands for freedom and spontaneity. It builds upon the child's natural love of things, and upon his innate tendency to investigate after his own fashion. The old style science teaching failed to appreciate this latter point, and endeavored to impose adult methods of investigation upon the child mind, with the inevitable result—failure, ignominious failure.

It is not the purpose of this paper to make any extended defense of nature-study and its methods; but rather to indicate what possibilities legitimately lie within its proper sphere; and to inquire as to the extent to which these principles may be developed and modified to suit the enlarging interests and capabilities of the child as he passes through the various grades of the elementary and secondary schools.

When the principles laid down by nature-study are properly applied by competent and enthusiastic teachers, we may reasonably expect pretty definite results along well defined lines. The child receiving such instruction will have his active interest in nature awakened, both scientific and æsthetic. He will be brought into sympathetic relations with the environment in which he must live. He will have a keen appreciation of the beauties of nature. His intellectual powers of observation, classification, arrangement, inference and deduction will be stimulated and rendered active.

The effect on our educational system of widening the field of nature-study will be far reaching and fundamental. It makes the experience, interests, and mental horizon of the child the determining factor in the selection of educational material, rather than any adult idea of what constitutes a liberal education. It does away with a large amount of formality and irksome discipline, by introducing more spontaneity into school duties. It teaches real things—using the child's sense perceptions, his first and most important avenue of knowledge. It interests the young child in that which is nearest to its life and experience, his immediate physical, intellectual, and spiritual environment. It fosters

more and more the method of studying things at first hand, and things that are at hand. It fully recognizes that children learn very little from the experience of others. It will ultimately become the center of educational thought, to which the merely mechanical subjects of reading, writing, and arithmetic shall be tributary. It demands that our subject matter and courses of study be arranged according to the established laws of development for the normal child, and not according to some pet scheme of analysis. It will modify the whole scheme of science instruction in the high school and in the university, first by changing our ideals and then our methods; second, by bringing science instruction into a little closer harmony with the life of the individual; and third, by evolving a series of science text-books based on correct pedagogy, instead of slavishly following the logical development of the facts of science.

The effect of nature-study on formal science instruction will be marked in many ways. It will impress the lesson that from the educational standpoint, the facts of science, without a "point of contact," are worse than useless—they are a positive hindrance to the fullest development. It will largely eliminate from science instruction all subject matter that is foreign to the life activities of the student. It will help to establish the rule of teaching that the development of the individual is of more importance than the development of any subject. And it is not improbable that it will serve to render science instruction less scientific and more æsthetic, insisting that technicalities be left to the specialist and the investigator.

It remains to us to show the unity of nature-study, and natural science, in order to harmonize the two and bridge over the apparent gulf that lies between them. Nature-study is precisely what it proclaims itself to be—the study of nature. Its subject matter lies in the kingdom of earth, air, sky, and water; it embraces a search for knowledge of all phenomena and the laws by which they are associated. Natural science finds all its subject matter in the same field, and it pursues its course towards the same end. In both nature-study and natural science, every thing depends on the integrity and proper use of the senses. In both the value of the subject to the individual depends upon his own observation and investigation. In both the aim is to have the pupil investigate phenomena and things for the purpose of determining their relations—of seeing the universal prevalence of law.

The methods of dealing with the two classes are essentially different, however, because of the difference of age and consequent development. Children have no ability to deal with the details of a subject but can see things in large masses.

Every step taken in science instruction should be a substantial preparation for the next step throughout the course, from the kindergarten to the university. But all the time it must not be forgotten that the child, his stage of development, his point of view, his power of comprehension, his interests, his needs, are to take precedence over any consideration of subject matter. It must be remembered that true education is a progressive adaptation of the individual to his environment. At first the process is comparatively simple, confined largely to the domain of sense perception; but as the individual gradually comes into closer harmony with his environment, the educational process becomes more complex.

So in any great department of knowledge, especially one that touches the life so closely as does natural science, the unfolding must be gradual, progressive, and well adjusted to the capabilities of the individual who is being educated. All sudden and radical changes of method must be eliminated. All parts of the system must be thoroughly coördinated. The unity of all science must be recognized; but it also must be recognized that such unity must be worked out through variety. In other words, the key note must be "adaptation"—adaptation of educational matter to the individual, and the adjustment of the individual to his environment, all working together to the end of complete living.

Such a view of the office and functions of the school demands a degree of professional training on the part of teachers not commonly met with. In fact the solution of the problem of harmonizing all parts of science instruction, as is true in all great educational problems, rests primarily on the training and efficiency of the teaching force. The teachers of this country have in their hands the making or marring of any educational policy that may be promulgated. They are the ones who come into actual contact and personal touch with the boys and girls. Educational philosophers may advance splendid theories that promise to do wonderful things for the schools, but the actual teaching force is the vital factor which stands between the theorist on the one hand, and the hard facts of human nature and social standards on the other hand. The teachers must bear the brunt of any failure of educational policy, and theirs should be the praises for any signal successes.

MATHEMATICS AS A FACTOR IN CHARACTER BUILDING.*

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Our mathematical history dates back to the Egyptian and Babylonian civilizations. The demands of practical life, together with something of the real scientific spirit, especially among the priestly caste, gave rise to a considerable degree of skill in mechanical operations, and also to some theory of the subject. But one manuscript has been preserved and that an Egyptian one written by Ahmes, about eighteen hundred years before Christ. This manuscript is now in the British Museum. It is entitled "Directions for Obtaining the Knowledge of all Dark Things." The small attention paid to theory is illustrated in this writing. There are no theorems in it. It contains "hardly any general rules of procedure, but chiefly mere statements of results intended possibly to be explained by a teacher to his pupils." In this work we find the first trace of an algebraic equation.

For the next forward movement in mathematics we span an interval of over one thousand years and look to the Greek civilization. The Greeks with their love of speculative philosophy gave their particular attention to but one branch of mathematics, geometry, and furnished to the world three of the greatest mathematicians of antiquity, Euclid, whose "Elements" are the foundation for all modern geometry, Archimedes, who applied mathematics to the originating of labor-saving machines, and Apollonius, the great writer on conic sections.

The Romans were so occupied with questions of road-building and other practical matters relating to the management of their vast territory that they had but little time for any theory relating to mathematics, but demanded only the applications. They wanted geometry in order that they might lay off land and buildings, and calculation that they might make account of their incomes and reckon interest and taxes, but further they did not care to go.

The Hindus took the garnered wisdom of the preceding ages and assimilated it, then proceeded to work out independent results. To them rather than to the Arabs we owe our present position number-system.

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The Arabs did not show similar independence of thought, but acted rather as translators and transmitters of the treasures of India, Persia and Greece. Thus when Western Europe was ready for it, they found a store of mathematical science close at hand.

Italy, through commercial relations with the Moors in West Africa and Spain, gave added impetus to commercial calculation, and also made some advances in theoretical work.

Yet even the German mathematicians were, until the middle of the seventeenth century, chiefly calculators. A few eminent men like Kepler carried on original investigation.

The modern period begins at the middle of the seventeenth century, with Descartes and analytical geometry, Leibnitz and Newton and the calculus. From that time the development of the science has been rapid, until it stands forth to-day a marvelous tribute to human reason.

We can afford to consider these steps in the history of mathematics, because we have thus forcibly brought to our attention the fact that in this subject we have an adjunct to our educational forces which has stood the test of the centuries, and has from these tests evolved a body of truth which must always be reckoned with as a factor in a liberal education.

Schubert, one of the foremost German mathematicians of the present day, in his "Mathematical Essays and Recreations" says, "The intrinsic character of mathematical research and knowledge is based essentially on three properties: first, on its conservative attitude towards the old truths and discoveries of mathematics; secondly, on its progressive method of development, due to the incessant acquisition of new knowledge on the basis of the old; and thirdly, on its self-sufficiency and its consequent absolute independence. * * * From these three cardinal characteristics, now, which distinguish mathematical research from research in other fields, we may gather at once the three positive characteristics that distinguish mathematical knowledge from other knowledge.

"They may be briefly expressed as follows: first, mathematical knowledge bears more distinctly the imprint of truth on all its results than any other kind of knowledge; secondly, it is always a sure preliminary step to the attainment of other correct knowledge; thirdly, it has no need of other knowledge.

"But after all it remains a useless accumulation of capital so long as it is not turned to practical account in other sciences such as metaphysics, chemistry, biology, political economy, etc."

A Frenchman once said, "One mathematician more, one man less." There was some point in this epigrammatic statement, for it came at a time when an effort was being made to trace all human virtues down to a foundation in mathematics. It is the purpose of this discussion to try to assign to the proper place in the structure of character, which it is the function of the school, correlating with the home and the church, to rear, the portion of mathematical knowledge which is essential to the fulfillment of this function. In so doing we recognize that it is but one of the parts of the structure.

Character has been defined as "a bundle of habits." Habit is the material from which character is built. Character is known by conduct and conduct is the result of habit. Character is what we are, reputation is what people say we are. We recognize certain virtues as essential to a good character. Such are the moral virtues of purity, temperance, courage, industry, self-respect, justice, and benevolence; and the intellectual virtues of sincerity, impartiality, concentration, accuracy, truthfulness, candor, proper reserve, consideration, prudence, and wisdom. Our concern is to discover, if possible, to what extent mathematics, particularly that portion of the science which forms part of the curriculum of the elementary schools, ministers to the cultivation of the virtues above enumerated.

We are assuming that character building is admitted to be the chief function of the school. The school cannot entirely make or unmake character, but permeating its courses of study and all its plans and methods must be that kind of influence which gives a strong bent toward the formation of the right kind of character. There is a spirit which animates a rightly conducted school, quite similar to that which pervades a true home; it is a comradeship, a feeling of mutual responsibility, a desire for the common good, which acts as a strong barrier against disorderly influences, and produces a class of citizens who are law-abiding and anxious for the best things in government.

However, the school and the teacher cannot form character; they can only aid in forming it. The formation itself must be the work of the child.

Concerning the means to be employed, we find the following statement in Dexter and Garlick's "Psychology for the School-

room": "The means at the teacher's disposal will include the use of an intelligent sympathy and the study of individual temperaments and dispositions; for temperament is natural character. The teacher must form moral habits in the children, he should utilize a proper classification of the virtues, and possess a correct apprehension of motives. They will include a course of special lessons for the teaching of the chief moral duties, and they will be utilized, and the discipline of the school will be fitted to its special task. The modifying effect of intelligent capacity will be noted and allowed for, and a full advantage will be taken of the school games for the observation of the unrestrained dispositions of the children. Finally, the means will include a practical recognition of the fact that the formation of character includes the cultivation of all the powers of the mind."

The youth who goes out from the school into the field of business or professional life is well equipped, if those entrusted with his early training have given him an opportunity to attain a mastery of all his powers and have so encouraged or restrained that he is masterful because of his knowledge of his grip upon forces which if released would wreck his career.

One of the virtues which we may develop by the proper teaching of mathematics is industry. Teachers of mathematics have one special advantage in their subject, it admits of exceedingly definite assignments of work. This makes it further possible to set a limit upon the time necessary for doing a certain portion assigned for a lesson, and thus a habit of industry is formed. The world is keenly in search of just such industrious people as are produced by this method. There is always a place for the man who does first things first and constantly has something coming. The tasks which filled a day of our earlier life are now done in an hour or two, because we have learned the real meaning of industry and can turn off work with great rapidity. An industrious teacher has industrious pupils. We do not to-day in our schools get by a large majority the amount of result which might fairly be expected from our equipment and the previous preparation of those whom we teach. We do not make large enough demands, in the first place, upon ourselves, and in the second place upon our scholars. The time is at present filled with varied duties, but frequently these duties are not of the kind which lead out into a larger view and a preparation for greater undertakings. In the teaching of Latin in a certain high

school in this state it was once deemed a good accomplishment if in three years the class had read two books of Caesar, two or three of Virgil, and two orations of Cicero. Gradually as students came to realize the possibilities of application the amounts read were increased until nothing was thought of getting over four and sometimes six books of Caesar, six books of Virgil, and six orations of Cicero. Not only was there a greater amount of reading done and the culture of the student correspondingly increased, but that which was read was more thoroughly understood, the interest was greater, and the quality of scholarship much enhanced.

Along with industry must come concentration. No one can hope to rank with mathematicians who does not possess this faculty in large measure. In fact he cannot rank very high anywhere. All great discoveries and successes in the history of the world have come about because someone excelled in this virtue. Just as the lens bends together the scattered forces of the sunlight and renders their united efforts capable of mighty results, so the well disciplined mind combines forces weak in themselves, but mighty for accomplishment when working together. We may pour a whole ocean of water over a hard clay bank without any very apparent result, but direct the water through the nozzle of a pipe and give it the head gained by some force acting upon it, and the hard clay melts away like dust. There is a wonderful satisfaction in seeing a page of difficult problems melt away before a well directed attack. A teacher has done a great thing for a lad when he has led him to realize his power to be the general in charge of such an attack as well as the rank and file who carry out the plan.

One is sometimes led to think that there is no opportunity under modern school conditions to teach concentration. The pupil is hurried from music to drawing, from drawing to numbers, from numbers to manual training, from manual training to reading, from this to that, with all intervals which might be utilized for breathing space devoted to physical exercises, until he gets into a perfect whirl. I have seen children chased around in kindergarten work until they came home thoroughly tired out. They had undoubtedly been kept out of mischief, but they had also been kept out of some other things, among them the opportunity to do some one thing for a long enough time to get familiar with it.

There is a reaction coming and in the saner days of the future we will wonder that we ever attempted so many different things in one short day of twenty-four hours.

No virtue is more commonly recognized as resulting from mathematical study than that of accuracy. This is the one thing for which the subject has always stood. While we might not be willing to endorse this attitude in its entirety, it is undoubtedly true that "though mathematical knowledge does not lead to absolutely certain results, it does invest known results with incomparably greater trustworthiness than does the knowledge of other sciences."

We may and we must insist upon the greatest possible degree of accuracy in results in mathematical work. This accuracy has a great many contributory factors. For instance, there is the arrangement of work. I have seldom, if ever, known a student who was by habit neat and careful in arrangement of his material who was not also accurate in his results. The same disposition which leads to careful placing of figures and to the arrangement of his material in readable form, leads up to a nicety of calculation which insures correctness in the end.

There is a happy medium between cut and dried formality of arrangement, and the scrambled eggs effect which is the ruling one in the average arithmetic paper. We wrong both pupil and teacher when we accept poorly arranged and slovenly papers, with results almost right, or only partially worked out. We need not be afraid of getting the pupil into ruts. Ruts and grooves are an absolute essential in the working of machinery. Imagine the removing of the grooves and guiding rods from some powerful machine, and its being left to work its own will. This virtue of accuracy is fundamental to success and its practice should be so machine-like that the mind never stops to think that it is or must be accurate. The world of business knows no such thing as almost correct. The books of the bank must balance at the close of the day's business, the merchant's balance must show all avenues of income and outgo and the relation between them. While we cannot in all respects require the absolute standards which obtain among mature men, we can set in motion forces which will tend to produce ability to conform to such standards in later years.

Self-respect comes in the train of mathematical victories, as well as in that of other triumphs over material, or less tangible

things. Genuine self-confidence, which has in it no trace of unpleasant egotism or self-sufficiency, is one of the most refreshing virtues. When a man can look you squarely in the eye and say that he can accomplish certain results, you involuntarily believe him. I know a capable architect and builder, a large part of whose success is due to the fact that he first makes himself thoroughly familiar with the plans for a structure and stands ready to answer all questions and to meet all assumed difficulties with the prompt assurance that he is ready to cope therewith. A member of a board under whose direction this man does a great deal of work, once told me that the builder's attitude toward apparently insoluble problems gave a feeling of confidence to the whole board. It is worth our while to give much time and thoughtful attention to the development of such a virtue. It cannot be done by coercion, but rather by encouragement. A young lady who is unusually gifted as a student and teacher of languages but born short in mathematics, came to me at one time in despair over her algebra. She had lost self-respect in regard to her mathematical ability and was ready to give up the battle, or rather to say that she could never do even fairly creditable work, and that it was all drudgery. A personal conference over the special phases of difficulty, and some suggestions as to attitude toward the subject, brought about a determination to develop a liking for the study. The last report is that she is beginning to like it. This liking or disliking subjects of study is largely a relative matter after all. We almost invariable like those pursuits in which we are able to attain a fair measure of success. The young lady in question will never rejoice in mathematical study as she will in that of language, but she has kept her self-respect.

Mathematics should develop a spirit of impartiality. The student performs certain operations, applies certain principles, and then stands ready to interpret results. Nothing is more deadening than to be tied down to always getting a certain form of answer, usually previously determined by another. This reduces his effort to a dead-level of routine which is bound to dwarf and belittle his powers. Unless he is able to grasp an unexpected form of result and determine its relation to the elements of the problem, and then assign it to its proper place in regard to these elements he has not tasted the enjoyment of mathematical power. Thus it follows that there should be a proper system of checks and balances.

I recently enjoyed a pleasant chat with a gentleman whom I met in the course of a journey by rail. He had at one time been auditor of the Iowa Central R. R. It was his business to look after the financial affairs of the road, keep tab upon all income and outgo, and report upon the result of his investigations at frequent intervals to the board of directors. I asked him about a matter which had always puzzled me. It related to the keeping account of all ticket sales by agents of the road, and their balancing with reports turned in by conductors and other officials. He said that he had a force of thirteen men at work all the time upon such matters, that there was a complete system of checking, complete as far as human ingenuity could make it, by which every form of ticket, pass, or other evidence of transportation was compared with the report made upon it by some agent of the company, and that any errors went straight back to the one making them, either to be explained or settled for in money. There was no place in this system for careless agents or conductors, and no scheme for palliating offenses due to slovenly methods.

These checks and balances must enter into all our life, not only into the material, but also into the mental, spiritual, and physical. The idea of an accounting, a rendering up of the results of our labors pervades the whole scheme for the human family. The question will meet each one some day, relative to what he has to show for this or that talent or opportunity, and he will be under the necessity of adding up the colums and checking his answers in order that he may give a faithful account of his stewardship.

We have enumerated several of the virtues which accompany the kind of character which we covet for the pupils in our schools. We have tried to show that there is great opportunity for developing industry, concentration, accuracy, self-respect, and impartiality. We might name many others, but we do not wish to force the comparison. The natural outcome of this kind of character is power, and power is what gives marks of distinction to men. Power is in demand. Men are harnessing Niagara, seeking for something to supplant steam, almost before steam has lived out its first century of active life. Business corporations are looking for men of power. I saw the statement recently that a great commercial enterprise needed a number of men of a type hard to find and were willing to pay almost fabulous sums to

secure and retain in their employ the right type of men, that is, men of power.

There is also great abuse of power. With the air full of insurance scandals, city graft, abuse of public office, commercial greediness and oppression, with a spirit of self-seeking abroad which recognizes no Golden Rule or Ten Commandments, it behooves the school as a guardian of future wielders of power, to attempt in every possible way to implant such principles as will make it impssible for one to betray a trust committed to him. The situation mentioned above renders it all the more necessary than any petty graft in connection with school affairs, any attempt to get something for nothing, anything less than straightforward and worthy attempts for success, be severely dealt with, and that as far as possible all such tendencies be removed from the school organization.

But one who sets out such a program as the above must in all fairness at least make an attempt to show how, in the teaching of some of the branches under discussion, his suggestions can be made to bear fruit.

Men have always studied arithmetic. Sometimes it has been for culture, sometimes for amusement, sometimes for mere ostentation, frequently as a quickener or whetstone of the wits, but more often still for its practical commercial applications. One sometimes tends toward the opinion that arithmetic and the English language, though receiving the most attention in our schools, are less understood than any other subjects in the curriculum. There appears to be a smaller amount of real and tangible outcome.

It is after all not so much a matter of method as of results and that method which gives the largest product in results is the best one. As a rule we teach too much arithmetic. For eight years of grade work and frequently for another year in the high school there is a wearisome repetition of the same operations in different exercises and examples until there is danger of arithmetical nausea. The part of arithmetic which is absolutely necessary for carrying on the business of the world is not large. The four fundamental operations with whole numbers and fractions, some tables of denominate numbers with the ability to reduce and combine same, parts of mensuration, and enough of percentage to compute discounts and interest, are all that are indispensable. These every scholar should know and know thoroughly, much

more thoroughly than they are usually known under present day conditions. Other parts of arithmetic have their proper place, but should always be subordinated to the demand of the essentials.

Algebra is to the average pupil an unknown region. He juggles with its symbols, substitutes in its formulæ, gets the answers to its problems as set down in the text, and then consigns it to oblivion. It is said that a young lady was once asked whether she had been through algebra, and replied that she had, but it was at night and she had not seen much of it. That is probably an extreme case.

There is no subject in the elementary course which is more questioned by students in regard to its practical value. We might give Euclid's answer. When a youth had learned his first proposition in geometry and asked: "What do I get by learning these things?" Euclid called a slave and said, "Give him threepence, since he must make gain out of what he learns." Professor Hudson has said, "To pursue an intellectual study because it pays indicates a sordid spirit, of the same nature as that of Simon, who wanted to purchase with money the power of an apostle. The real reason for learning, as it is for teaching algebra is, that it is a part of Truth, the knowledge of which is its own reward."

Algebra, in order to give the best returns in power, must always be presented as a larger view of the number system than arithmetic. Its proper presentation should give breadth of view and respect for its prominent relation to subsequent subjects of study. The theory of astronomy, of physics, and of mechanics, the fashioning of guns, the computations of ship building, of bridge building and of engineering in general, rest upon the operations of elementary algebra.

It is more difficult to avoid mechanical work in algebra than it is in arithmetic, because it is based upon formulae and offers abundant opportunity for substitution in these formulae with little appreciation of the reason for the formulae or the principle underlying the substitution. The teacher must constantly guard this tendency and strive to create a living interest in the subject.

Geometry has its twofold value—the practical value and the culture value. Its practical feature lies, of course, in mensuration. Of the other side it has been said, "Here, then, is the dominating value of geometry, its value as an exercise in logic, as a means of mental training, as a discipline in the habits of

neatness, order, diligence, and, above all, of honesty. The fact that a piece of mathematical work must be definitely right or wrong, and that if it is wrong the mistake can be discovered, may be made a very effective means of conveying a moral lesson. Without this aim well in mind, the teacher is like a mariner without a compass; he knows not whither he is to go; or, if he has some confused idea of the haven, he has not the means to find his way thither."

It is much more difficult to render the study of mathematics thoroughly interesting than is the case with most other subjects. Its value in character formation will be greatly enhanced if, by supplementary material the grind of daily work is somewhat smoothed. Teachers have not given as much attention to this phase of their teaching as they should have done. Some historical study will be helpful here. On this point Cajori says, "A class in arithmetic will be pleased to hear about the Hindoos and the invention of the 'Arabic notation;' they will marvel at the thousands of years which had elapsed before people had even thought of introducing into the numeral notation that Columbus-egg-zero; they will find it astounding that it should have taken so long to invent a notation which they themselves can now learn in a month. After the pupils have learned how to bisect a given angle, surprise them by telling them of the many futile attempts which have been made to solve, by elementary geometry, the apparently simple problem of the trisecting of an angle. When they know how to construct a square whose area is double the area of a given square, tell them about the duplication of the cube—how the wrath of Apollo could be appeased only by the construction of a cubical altar and how the mathematicians long wrestled with this problem. After the class have exhausted their energies oo the theory of the right triangle, tell them something about its discoverer—how Pythagoras, jubilant over his great accomplishment, sacrificed a hecatomb to the Muses who inspired him. When the value of mathematical thinking is called in question, quote the inscription over the entrance into the academy of Plato, the philosopher. 'Let no one who is unacquainted with geometry enter here.' Students in analytical geometry should know something of Descartes, and, after taking up the differential and integral calculus, they should become familiar with the parts that Newton, Leibnitz, and Lagrange played in creating that science. In his historical talk it is possible for the teacher to

make it plain to the student that mathematics is not a dead science, but a living one in which steady progress is made."

There are, we firmly believe, great possibilities within the grasp of the teacher who earnestly tries to develop character by mathematics as well as by other subjects of study. It is not after all so much the subject as the way in which that subject is presented which is going to determine its effect for good or evil.

CORNELL'S SUMMER SCHOOL.

The sixteenth summer session of Cornell University which closed on August 15 has been the most successful since the university inaugurated the movement. Seven hundred and fifty-five students were in attendance. Of this number 288 were undergraduates now attending Cornell and sixty-two undergraduates from other universities. One hundred and fifty of those in attendance were college graduates. Three hundred and two were persons now actively engaged in teaching; 22 in colleges, 18 in normal schools, 17 in private schools, 111 in high schools, 120 in grammar schools, and 14 in the work of superintendence. The attendance included persons from forty-one states and territories of the United States and from eighteen foreign countries. Instruction was offered in 22 departments by 41 professors, 16 instructors, and 14 assistants, all but 12 being from the regular teaching staff of Cornell. Those from outside were drawn from universities: Nebraska, Michigan, Purdue, Princeton, from Trinity College of N. C., from the State Normal Schools of Illinois, and of New Jersey, and from two of the high schools of Greater New York.

The peculiar advantages which Cornell offers for summer study by reason of her beautful location and the value of the surrounding country for all field work were never more apparent than this year. The hearty and energetic participation by so many of the best teachers of the faculty assured the best possible use of these advantages of nature and of the large educational plant, all of which is placed without reservation at the service of the students in attendance. It is the universal testimony of teachers who have used a part of their vacation in study at Cornell that the suggestion and inspiration given them has been of immense value.

CHEMISTRY SYMPOSIUM.*

I. *What to Put in a Notebook.*
II. *When and Where Should the Notebook be Written Up.*
III. *Corrections of Notebooks.*

(*Continued from the October number.*)

LABORATORY NOTEBOOK IN CHEMISTRY.

By Harry Clifford Doane,

Central High School, Grand Rapids, Mich.

I. What to put in the notebook.

The makeup of the notebook will in a measure depend upon whether we wish our pupils to produce beautiful notebooks for show and to present at college or to make them simply for their value as a means of teaching chemistry. For myself, I hold that the notebook should be for the purpose of teaching only. While there is a certain value in the ability to produce fine looking notebooks and we should never in any school work neglect the items of neatness and appearance, yet we are teaching chemistry, and the making of notebooks should be incidental.

The notes should be as brief as is consistent with good work, to save the pupil's time of writing and to save the teacher's time and effort in correcting. We should strive to reduce the routine drudgery as much as possible. Some teachers are slaves of the routine work. The teacher who puts all his energy into looking over papers and notebooks robs his class of the enthusiasm that he should put into his work.

In my own laboratory work I have prepared the directions with a view to reducing the amount of the notes to the minimum. The notes are on loose leaves and are bound into the same cover with the directions. Each question has its individual number and the pupil writes only the result or answer, repeating only such of the directions as is necessary to definite statement. No descriptions of apparatus are required, as this would be simply repetition from the directions. The pupil does not tell what he has done, but what has happened. The notes are complete only when read in connection with the directions. This method reduces the work of looking over books fully one half.

In using this plan it is quite necessary to insist that the numbering of each result and answer in the notes shall correspond exactly with that in the directions. This is no loss to the pupil.

*Read before the conference of Chemistry, a section of the Michigan Schoolmasters' Club, March 28, 1907.

Our pupils need to gain the ability to follow a prescribed form.

This scheme can be much more easily carried out if the teacher prepares his own laboratory manual, and this is always preferable. It enables one better to adapt the work to his time and equipment than by selecting from a manual prepared by someone else. It also gives one an opportunity to carry out his own pet notions, which has its value. We will do better work in our own way than in a manner prescribed by someone with a different viewpoint.

II. When and where should the notebook be written up?

To my mind this is not a debatable question. Of course, more work can be accomplished by allowing the notes to be prepared outside of the laboratory, but it is invariably destructive of independent work on the part of some pupils. There are those who will always copy from others under such conditions. Some assistance will be obtained where the notes are prepared in the laboratory, but to a much less extent. The ideal laboratory would be equipped with individual desks and each experiment would be performed individually. Then we could reduce the element of illegitimate assistance to the minimum. However, there are some experiments on which it seems wise to allow two pupils to work together, especially in a laboratory like ours in the Grand Rapids Central High School, where there are no ventilating hoods and no special ventilation at each desk.

This matter of illegitimate help is a serious one. Our schools are permeated with this sort of dishonesty and I suppose have always been to a greater or less extent, but we need to remember that one of the most important objects of school is to teach honesty and every teacher should frequently impress the need and value of honesty by percept. It is far more important that we teach honesty than chemistry.

III. Correction of notebooks.

I can best give you my ideas of the proper correction of a chemistry notebook by describing the method that I use. The notes of the first two or three experiments are written in pencil and corrected by the instructor before being placed in the notebook. This is to familiarize the pupil with what is required. Thereafter the notes are put directly in the notebook in ink. After each week's work the notes are corrected by the instructor with a pencil. Letters are used to indicate the more common errors. If the difficulty is too complicated to be easily indicated

it is marked with a "C," meaning "Consult instructor." The pupil then so corrects the notes as to make them read correctly, making the corrections show as little as possible, trying again such parts of the experiments as are marked for retrial. He then brings the notes to the instructor for approval during the laboratory period. This gives an opoprtunity for questioning. When the corrections are completed the instructor affixes his initials with a rubber stamp. The pencil corrections may then be erased by the pupil.

This method will not produce fine looking notebooks for any except the best pupils. Corrections and interlineations are too many. The same method practically might be followed with a saving in the appearance of the books by having the notes for each experiment written on a separate sheet. Then the corrections could be made under the title "corrections" following the original notes. I am not sure, however, that this would be an improvement and it is hardly feasible in our school where the notebook paper is furnished by the institution.

I find that the making of corrections by the pupil is more of a test of his ability than the original making of notes. Frequently where the notes of two pupils are of about the same value one will proceed intelligently with the corrections and the other will not. This demonstrates the necessity of having the pupil correct the notes and repeat those parts of the experiments in which he has failed to observe correctly the results. The practice followed by many teachers of simply marking errors at random intervals or at the end of the semester and not having the pupil make corrections may possibly be all right in some subjects, but it has most serious objections in chemistry.

Attention should be given to errors in spelling, punctuation, grammatical construction, and all that goes to make technically correct English. Too many teachers are careless in such matters in their own writing as well as in the correction of pupil's notes. One of the most important duties that falls to the science teacher, both in the recitation and in written work, is the teaching of the accurate use of words. While the English teacher is supposed to teach precision in the use of words, yet in the effort for variety of expression the pupil sometimes loses sight of this.

One of my pupils, who was specializing in literature at college, told me that he found that the work in high school chemistry and physics had done much for his composition. In these

he learned to write accurately and definitely. I believe that we can perform the same service for many of our pupils. We must give some attention to the teaching of accurate English if we do all things with the thoroughness and accuracy that are supposed to belong to good science work.

The ability to do things in a prescribed way and the putting of matter into prescribed forms is important in practical life. The inability to do so indicates a certain lack of self-mastery. The laboratory notebook may be made an excellent means of gaining this power.

It has been my privilege to serve for several years as a member of the committee which audits the accounts of the officers of pupils' organizations in our school. We find that not half of our juniors or seniors can follow the simple directions which are prescribed for these accounts and the directions are such as to require no previous knowledge of bookkeeping. The boy or girl who can write up his notebook properly as directed can hand in businesslike accounts to the auditing committee. This simply illustrates the practical side of the matter. It is not always a bad thing when some of our pupils think that we are over particular in insisting that work be done our way and not theirs.

The notebooks are a burden to the teacher. Let us make them as little so as is consistent with first class work. Still, sometimes so dry and prosy a thing as a notebook may be the source of amusement. One of my boys said that there was left in the bottom of his evaporating dish a sentiment. We may not have thought of laboratory work as productive of sentiments, but we certainly do know that it is frequently a source of joy both to pupil and teacher.

THE CHEMISTRY NOTEBOOK.

By F. C. Irwin,

Detroit Central High School.

In writing the notebook we ask the pupils to state, 1st, the name and purpose of the experiment; 2nd, familiar materials in which the substance occurs and materials most convenient for preparing it; 3rd, the apparatus used in its preparation and collection; 4th, the record of a series of tests to determine its most characteristic physical and chemical properties, and 5th,

where possible, some application of its use in everyday life. The completeness of the description of an experiment will vary somewhat according to its position in the course and also to the nature of the exercise. Explanation of details that we insist upon early in the course, for example, collection of gases, use of safety devices, we touch only lightly or pass over later in the year. Also a quantitative exercise like the determination of the equivalent of magnesium requires different treatment from a qualitative experiment, as the preparation of hydrogen.

Since, however, the qualitative experiments predominate, in which the observation of physical and chemical properties is an important purpose, let us consider this type of experiment. The study of oxygen will illustrate. I think it is an advantage to preface this experiment with a few simple tests on combustion, for example, the burning of a magnesium ribbon and weighing the product, collection and weighing of the products of combustion of pine splinters or a candle. The student is invariably greatly surprised to find the increase in weight. This awakens his interest and he is ready to take up the study of oxygen with enthusiasm.

At this point, I think it is wise to follow the historic order. Give each student a test tube, about 5 grams of mercuric oxide, and a splinter. Direct the work orally and I think the class will derive much more benefit than they will by following the test from a manual. Each student has a small notebook before him and records the progress of the experiment as he completes each test. After obtaining the oxygen test from heating mercuric oxide, let each one heat a small amount of potassium chlorate alone and then of potassium chlorate and manganese dioxide together, noting the much lower temperature at which oxygen is given off.

The student is now ready to set up an apparatus for preparing a larger amount of oxygen. He collects several bottles of gas and makes the usual tests. He writes this as the usual method for preparing oxygen, making also an accurate diagram, not a picture of the apparatus. Finally as a lecture experiment we set up the combustion furnace for oxygen from manganese dioxide alone, and show also the preparation from sodium peroxide and water. These methods also he mentions in his notes. An ambitious student makes a good diagram of the combustion furnaces.

After a study of this nature, nearly every student will feel proud of his achievement and will be ready for more concise work on many of the succeeding experiments. Notes on all points are made in the laboratory.

The students' temporary notes are inspected by teacher at the time of the experiment as far as possible. From these notes the student writes up the experiment at home in a good permanent book. The permanent book is examined by the teacher every week early in the year, or every two weeks later when fewer corrections are necessary.

A good deal has been said about the apparent waste of the student's time in requiring him to write up his permanent book outside of laboratory hours. After trying both methods, writing the permanent notes in the laboratory, and writing them outside. I do not find that any considerable waste of time occurs in the second method. Several years ago, with small classes and plenty of time in the laboratory, we furnished each table with pen and ink and required each student to make his original notes in permanent form. If this method were followed now, with the larger number of students and the shorter time placed at the disposal of each section, the student would lose the continuity of the study and lose interest in the experiment before he could possibly complete it.

I find also that it is a good expedient to allow the student to go over his work again in writing up a permanent book outside of the laboratory.

To summarize then: The student's notebook should be a pretty complete record of his work in the laboratory, written concisely and in good English, with a definite statement of what each experiment really teaches. These notes should be taken briefly during the laboratory hour, and written in the permanent book later.

Finally, in regard to correction of notebooks, I think we agree that best results are obtained by personal conference with individual students. This can be arranged with a limited number by making engagements before school or at the recess period. Since all the students cannot be reached in this way, we take a portion of a recitation period once in two weeks to discuss frequent errors and corrections. By this means we have usually succeeded in bringing out satisfactory notebooks. The most important point, however, is to stimulate the student's interest and pride in his work.

THE CANALIZATION OF STREAMS.

By Robert Marshall Brown,

State Normal School, Worcester, Mass.

The traffic of the Mississippi River has fluctuated during the last thirty years. With the fluctuations there has been at the same time a constant decrease in the volume and tonnage of trade products transported along this water-way. The improvements of the low-water channel, while they have been efficient as far as the project of the maintenance of a channel is concerned, have not given the expected impetus to the use of the river as a commercial route. There is the handicap still of an uncertain passage during the low-water season even though the years of dredging are considered successful, and though the experience of the last ten years makes the engineers confident that the 250-foot width and 9½-foot depth of channel of the dredging project is easily within the capacity and power of the corps and plant. Add to this, the possibility of the river falling to an extremely low stage, the restrictions and dangers during the flood stage of the river, the tortuous path, making the distance from Cairo to the Gulf three times the distance by air-line, the diversion of some trade to other paths and the competition of the valley lines, and we have the sum of the conditions affecting the river traffic. On the other hand, there is an increasing need of transporting lines out of the Great Valley. While the mileage of railroads is increasing, the demands for transportation are increasing with greater strides. Railroads are not giving the desired service. There seems to be ground for believing that the efficiency of the railroad lines has been sacrificed by straining the transporting power beyond a normal capacity. There is arising in the Mississippi Valley an increasing demand for better service. There are men in the valley who believe that the Mississippi River offers exceptional advantages as a trade route, but not under the projects now in operation. There is heard the cry that the river must be canalized. "The cry has gone out from the Dakotas that wheat is rotting in the bins because there are not enough cars to carry it to market; from Nebraska and Iowa that corn is molding in the cribs because of exorbitant railroad tariffs;"* from Texas, Arkansas, Illinois, Mssouri, and all the other states of the valley that transpor-

*Quotations are from Our Great River, W. J. McGee, World's Work, XIII, 8576, February, 1907.

tation service is not rendered to people and industries with the efficiency and dispatch which they consider their due. That the service cannot be rendered by the present lines is generally the belief. "Over all sounds the confession of the railroads that they cannot meet the demands for transportation without more cars, more locomotives, and more tracks." Consequently, the people of the Great Valley are turning to their great water-way as the only means of relieving their distress. They recognize that the present improvements of the river are not adequate to the needs of commerce; they foresee that under proper training a constant and efficient canal-way may be substituted for the low-water stage. Realizing the helplessness of their industries under the present regime and the threatened stunting of their growth, and on the other hand divining that the canalization of the Mississippi River is a remedy, the speakers for the people are pressing their claims in no uncertain tones. "They do not want to press matters, but— —, if they must, they have the votes, they have the means as well, to secure the traffic facilities on which their prosperity depends."

There are in extensive operation three processes for regulating the low-water stage of a river to the demands of navigation: training works, which confine the water under a low stage within narrow limits so that the increased depth of flow may be an instrument in scouring and maintaining a channel; dredging, where the deposits are removed from a shoaling channel as fast as the river falls in stage; and canalization, which turns the river during its low water season into a canal. Regulation by training embankments is in use on the Rhone. A rather swifter flow of water than is found in most navigable streams is instrumental in making these works effective. The suggestion of low-water levees on the Mississippi River was made a few years ago but the plan had but few commendatory features and was abandoned. Regulation by dredging is the process in operation on the Mississippi River. It is an unending process, the results of one season do not last through the spring floods to the next season. Oftentimes, a cut dredged early in the season may fill two or three times during the season under the deposition of sediment made at falling stages of secondary rises of the river. The results of the last ten years do not seem to satisfy the requirements for navigation. The dissatisfaction

never assumed definite shape nor was it in any way trenchant until now, when we are told that, like it or not, the Mississippi River must be canalized. It is my purpose to instance two or three cases of successful canalization and to point out one or more concomitant problems. If extensive plans of this nature are being advocated and urged for our Great River, a few notes in anticipation of the larger discussion may, at least, be timely.

Canalization is not a new way of gaining navigable depths of streams. It is in a cruder way the method often used by log-men to float their season's cuttings to the mill or market. The lock has its prototype in the stanch which was used for flushing so-called floatable streams. While the stanch affords intermittent navigation down stream only, the locks under canalization make navigation equally easy up and down stream. Canalization yields a definite depth of water and this depth can be maintained throughout the low-water season. Under extreme low-water stages, training levees and dredging projects must fail in maintaining a navigable channel. A canalized stream might lose so much water by the operation of the locks and leakage that in the dry season the channel would be affected. There is, however, a relief against this in storage reservoirs, if such relief should be necessary.

A good example of canalization is found in the Moldau and Elbe Rivers in Bohemia.* The Moldau River flows into the Elbe at Melnik. From Prague on the Moldau to the Elbe the river drops 82.5 feet; and on the Elbe from Melnik to Aussig, near the boundary line of Bohemia, 70.3 feet. This makes a drop of 152.8 feet in about 80 miles. The rivers to Prague were practically unnavigable during a part of the year. Canalization has so far improved these rivers as to provide a minimum depth of 7 feet from Aussig to Prague. Thus vessels of some 700-800 tons may reach the latter city at any season of the year.

Still better examples are found in the Seine† and the Main, a tributary of the Rhine. The Main was, for a season, regulated by training works which yielded a 3-foot channel from Frankfort to the Rhine. Canalization was tried and the depth of channel was thereby increased to 6½ feet. The traffic under the former method was 12,000 tons, under canalization 300,000

*Canalization on the Elbe and the Moldau. Scientific American Supplement, 57, 23598, 1904.

†Rivers and Canals. L. F. V. Harcourt, 1896.

tons. Later, during 1889, the navigable depth was increased to 8¼ feet by increasing the height of the canalization plant. The traffic in 1892 is reported to have been 709,000 tons. In this river the locks are 4 2-3 miles apart.

In the Seine there is a tidal water-way from the sea to Rouen. From Rouen to Paris locks 13½ miles apart yield a depth of 10½ feet and allow vessels of 1,000 tons to reach Paris. Above Paris, as in the Main, the locks are 4 2-3 miles apart and this distribution of locks yields a depth of 6½ feet. Canalization is more costly in the upper parts of valleys than in the lower because of the increased number of dams required, although there is some compensation in the decreasing width of dam necessitated.

This method of improvement is in operation in the United States, notably on the Ohio, where a series of 18 locks and dams furnish a channel 8 feet deep and 100 feet wide.*

It is generally the custom to locate the locks in a chute made by an island and to block the flow of water in the main channel by dams or wiers. Where no islands appear in the river, as in the Main and the upper Seine, the locks are placed in artificial side cuts or close to one bank. The wier is the true barrier to the flow of the river and its height determines the depth of the river above it. The distance between wiers depends on the slope of the river and the minimum depth of channel required for navigation. In rivers of heavy floods, these wiers must be movable so as not to be destroyed by the force of the waters. The locks in a chute or in an artificial cut, inasmuch as they are only a small portion of the stream and not in the main line of scour, do not receive much of the flood attack. The movable wiers are constructed after various patterns. In some rivers, because of the suddenness of floods, an automatic opening of the wiers is necessary. On the Ohio, the wiers are of a wicket pattern; the wickets being lowered when the river approaches high-water stages. These wickets are supported by a prop, and are hinged a little above the center at the points where the props are fastened to them. The effect is that as long as the water is in a low stage the wickets are kept shut by the force of the water against them. High water, on the other hand, throws the weight on the upper parts of the wickets and tilts them, allowing the water to escape.

*Waterway Improvement on the Ohio. Scientific American, 89, 117, 1903.

The canalization of the Mississippi River will be an enormous task and will call for a large expenditure of public money. The sum already spent for the protection of the basin and the improvement of the low-water navigation aggregates over $52,000,000. The projectors of canalization are talking in terms of three and four times that sum for minimum demands. There are certain features of the river that will tax a canalization plant to the utmost; there are other features that mean nothing more than extensive works, much labor and time for the accomplishment, backed, of course, by lavish appropriations.

The river is a sediment-bearing stream. It transports to the Gulf annually 400,000,000 tons (about 247,000,000 cubic yards) of detritus. This is three times the amount carried by the La Plata in the same length of time, six times that of the Hooghly and the Danube, and eight times that of the Nile. This amount of material will be detrimental to canalization. It is difficult to see how such works can be successful unless the detritus is removed before it reaches the lower river. It is suggested that settling basins be utilized at the headwaters of navigation, that the sediment be eliminated from the tributary streams before such headwaters are reached and that the 400,000,000 tons of sediment be retained "in the townships where it belongs."

The river has a flood season during which an enormous amount of water sweeps down the valley. The difference between the high-water stage and the low-water stage is in some instances over fifty feet. The present works are scarcely able to cope with the floods and vigilance does not always prevent disaster. Not every year is a heavy flood experienced. There comes, however, a year in the course of time when a heavy flood fills the river, when the efforts to restrain the waters, to prevent caving in dangerous places, to give the inhabitants of the basin protection, seems of little avail. In this fluctuation of flood heights, it is always conceivable that the highest known flood may be excelled. Any training works in the river must engage this flood season force and better it. On the fall of a a flood in stage the present navigable quality of the river depends to a large degree. After a sudden fall in stage, a heavy deposit of detritus is dumped along the bed of the river and navigation can be kept open only by persistent dredging. Like sudden falls in river stages must still occur, and if I am allowed

to doubt without being accused of casting aspersions upon a scheme the consummation of which will so largely benefit us, I should question the feasibility of handling this detritus, ordinarily deposited in inverse proportion to the diminution of volume of water, in the manner already suggested.

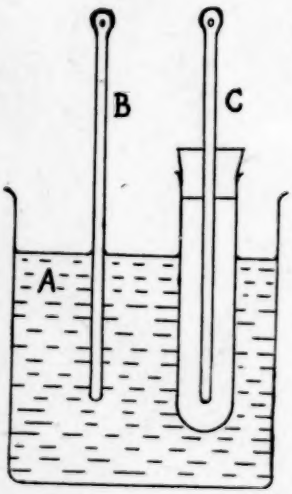
The river is a long pathway to the sea. The distance from Cairo to the Gulf is about 600 miles as the crow flies, while the waters of the river travel over 1,700 miles to make the journey. Meanders occur which add ten to fifteen miles to the water-way with only a mile gain towards the sea. This means time and expense. If, without endangering the regimen of the river, the locks were located across the necks of lobes where chutes are sometimes found and the wiers built in the meander bends this problem would be solved to the greatest benefit of traffic. This is the plan in use to some degree in the Main. In addition to the shortening of the waterway, it has the advantage of interfering in only a slight degree with the original channel of the river. Certain conditions seem to veto such a plan for the Mississippi River. Whether it is chimerical or not, must be answered by trial rather than by argument. It is not to be understood that the entire length of the river south of Cairo needs regulation. It is likely that a long reach of the lower river has a sufficient depth for navigation throughout the low-water season. Above Cairo, there is a stretch of river extending to St. Louis which appears not to have merited an appropriation equal to the allotment of past years in the eyes of the River and Harbor Committee in Congress. Along this reach of river an 8-foot depth of channel has been attempted but not always maintained.

The river is of gentle slope. The elevation above the Gulf at Cairo of ordinary low-water is 279 feet. This fact may be an aid to canalization by allowing a wide separation between locks. The great width of the river will, on the other hand, tend to make such works expensive.

All this is project. We were prepared to hear of some definite specifications when Congress considered the River and Harbor Appropriation Bill. That bill is now (Feb. 18) being discussed in the House. In general there is no provision made for any extensive change in the present project for the river. Furthermore, while the total appropriation asked for in the bill is much larger than for any previous year, some portions of the Missis-

sippi River have been allotted a smaller share than formerly. An instance of this is the allotment for the St. Louis to Cairo section of the river. The appropriation for this portion is reduced from $650,000 to $250,000. There is also a suffcient protest against any change of policy in the improvement of the river that such a radical plan as canalization must be more carefully considered and presented before it can gain supporters enough to permit the trial. Anyone, reading carefully the reports of the engineers who have worked upon or studied the river, cannot fail to be impressed with the general lack of agreement among them concerning the projects now being undertaken. While the cry for a 14-foot waterway from the Lakes to the Gulf meets with little opposition, the means to that end have not been so thoroughly canvassed as to commit a large enough following to any single policy.

TO SHOW THE POOR CONDUCTIVITY OF GASES.



The following simple plan to show the poor conducting power of gases is due to Mr. W. M. Butler of the McKinley High School, St. Louis.

The figure makes the experiment clear. A is a beaker of boiling water; B is a bare thermometer; C is a thermometer jacketed by enclosing it in a test tube, using a rubber stopper to support it centrally and prevent contact with the walls.

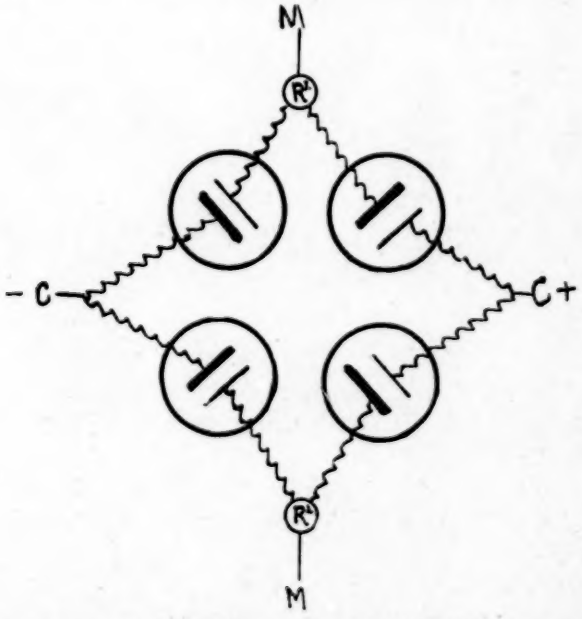
In an actual trial B rose to the boiling point in about ten seconds; A in ten minutes rose to but 80°, which is certainly a striking illustration of poor conductivity.

THE NODON VALVE; OR AN EFFICIENT RECTIFIER FOR A DOLLAR.

By Cyril O. Smith,

The High School, Hilo, Hawaii.

In the October, 1905, number of "School Science and Mathematics" there appeared a most interesting article by Prof. De-Forrest Ross on the making of a simple piece of apparatus for use in any school laboratory equipped with the alternating current, and what follows is also written for those who have this current at their disposal, but are without the direct, or rather are dependent on primary batteries with all the inconvenience, annoyance and expense for light work requiring a continuous current.



At the expense of a dollar or so, a Nodon Valve may be constructed which connects through any lamp socket with the alternating system, and the rectifier I have constructed in giving me sufficient current to perform experiments in electrolysis, work a couple of small motors, run a Ruhmkorff's Coil for wireless demonstration work and charge a storage battery, and not only doing this, but ready to do a great deal more, as occasion requires.

All that is required is four heavy battery jars, some heavy sheet lead, some sheet aluminum, eight binding posts, a few lamps of different candle powers of the voltage of the alternating system and a saturated solution of ammonium phosphate in distilled water.

Cut out four sheets each of lead and aluminum of a size to fit comfortably in your battery jars, fasten a binding post to each sheet, and place in the battery jars already filled with the saturated solution of phosphate of ammonia, and connect up as in the following diagram:

Heavy lines represent lead plates, light lines aluminum plates. Alternating current mains are connected at M, lamp resistance is placed at either R^1 or R^2, and rectified current is taken off at C— and C+.

If you can control your alternating current by means of a good lamp board, you will be delighted with the flexibility of the rectified current, but such a board is by no means a necessity, as for most light work a lamp of a hundred candle power, a fifty, a thirty-two, and a sixteen will be all that are required. My coil for wireless work is operated with a so-called one hundred candle power stereopticon lamp and an ordinary thirty-two candle power lamp in multiple, and runs with such freedom from trouble that the mere thought of a return to primary batteries is decidedly distasteful.

The following precautions are necessary to insure success:

1. Use distilled water if possible. If not, use very carefully collected rain water. Tap water will not do at all.

2. Add distilled water when necessary to take place of that evaporated.

3. Give both lead and aluminum plates a good scraping once in a while, and be sure and have them quite clean before starting up the first time.

4. Have everything set up over night, as rectification seems to start up more easily after plates have been in the ammonium phosphate solution some hours.

5. If too much foaming takes place with the particular load you are carrying, use larger jars and larger plates.

NOTE ON THE SOLUTION OF THE EQUATION $\frac{a}{x}+\frac{b}{y}=c$ FOR $x=y=0$.

By G. A. Miller,

University of Illinois.

In the October number of this journal Mr. Tripp considers the given equation from a point of view which involves dividing by zero. As this involves a point of great importance in elementary mathematics it may be of interest to quote a few recent statements which were made by very prominent authors and relate to this matter. These statements do not prove that there is only one way of looking at the problem and they are given mainly to show that our elementary algebras have a large number of the foremost mathematicians of the world on their side when they give, in general, only one set of values for x and y in the solution of two simultaneous equations of the form

$$\frac{a}{x}+\frac{b}{y}=c$$
$$\frac{a'}{x}+\frac{b'}{y}=c'$$

On page 19 of the recent work entitled "Lectures on the Theory of Functions of Real Variables" by Professor Pierpont of Yale University we find the following statement: "Division by zero is excluded in modern mathematics. The admission of division by zero by the older mathematicians, Euler for example, has caused untold confusion. We shall see it is entirely superfluous." The matter has been stated in greater details by the noted Italian mathematician Cesàro of the University of Naples in his work recently translated into German by Kowalewski under the title "Elementares Lehrbuch der Algebraischen Analysis und der Infinitesimalrechnung." On page 183 we find the following: "The functions

$$y=\frac{1}{x},\quad y=\frac{x^2}{x}$$

cannot be regarded as defined in an interval which includes 0, unless it is added that they have a value when $x=0$. In this case their value may be chosen arbitrarily; in fact, the results $\frac{1}{0}$ and $\frac{0}{0}$ which are obtained by making $x=0$ in the second members of the given equations *have no meaning* since the quotient of two numbers has not been defined in arithmetic or in algebra

except when the divisor is not zero. It would be possible to assign a value to these symbols, but this is not necessary and it would even be a disadvantage inasmuch as the generality of the algebraic operations is not preserved. At any rate, one should never say that $\frac{1}{0}$ is infinity and that $\frac{0}{0}$ is indeterminate."

I take it for granted that the leading mathematicians of all countries agree that one of the most reliable sources of information on elementary mathematics is the "Encyclopädie der Elementar Mathematik" by Weber and Wellstein. On page 59 of the second edition of the first volume, published in 1906, we find the following statements: "The equation $y=bx$ has either no solution or an entirely indeterminate solution when $b=0$. This is the reason why dividing by zero and fractions whose denominator is zero are excluded from arithmetic once for all. In certain parts of higher analysis it is, on the contrary, an advantage to assign a value to the symbol $\frac{1}{0}$."

The great French "Encyclopédié des Sciences Mathématiques," based upon the German work which is now in the process of publication, seems destined to become easily the most important mathematical encyclopedia in any language. In treating division on page 45 of Volume I, Tannery and Molk make the following statement: "It is understood, once for all, that the divisor will never be zero." On page 50 we read, "With the single restriction that division by 0 is always excluded." The number of such statements is very large and we have selected only a few from the most eminent authorities in various countries to establish the fact that the writers of elementary algebras who do not consider solutions which might possibly be obtained by considering division by 0 can defend their position wherever eminent authority is the tribunal.

For the sake of completeness we may say that the equation under consideration was treated recently in the *American Mathematical Monthly*, volume 14, page 49, under the title "Dividing by Zero." It seems to the writer that the treatment of some of the trigonometric functions in most of our elementary trigonometries is not in accord with the quotations given above. A few remarks on this point are also found in the said article on dividing by zero. We should perhaps add for the sake of clearness that the two equations $\frac{a}{x}+\frac{b}{y}=c$ and $ay+bx=cxy$ are not

equivalent according to the authorities cited above but the loci of these equations, in general, differ only with respect to one finite point and the largest microscope in the world would not reveal a difference between these loci if they are composed respectively of all the points whose coördinates satisfy the given equations.

AN EXPERIMENT IN LIGHT.

By A. L. Cavanagh,

Los Angeles High School.

In the demonstration on page 411 of Milliken and Gale's text-book I find the students are led to believe that the apparent location of the image in water is determined by the relative velocities in water and in air of the light waves. The wording seems to be an unfortunate one in that the change of form or curvature of the wave front is not emphasized.

The increase in velocity of a wave upon passing into a medium of less optical density does not necessitate an apparent approach of the image to an observer in the less dense medium. I insert here a little class experiment which I use to make this point clear and to show the effect of the curvature of the wave front in locating the image.

A large circular glass dish—I use a crystallization dish about eight inches in diameter but a larger one would be still better—is filled with water and a pencil is plunged vertically into the water and viewed by the class through the curved side of the dish. If the pencil is near the front of the dish the immersed part of the pencil appears nearer than that part seen in the air. At the center of the dish the pencil appears continuous, while at the far side the immersed part is farther away.

In the first position the waves upon entering the air are rendered more convex according to the demonstration referred to in the text-book. In the second position the wave front is not changed in form and consequently appears to come from its true source. In the third position, the wave fronts become less convex in passing into the air and appear to have a more distant source than the real one.

In each case the waves experience the same change in velocity as they enter the air.

PROGRESS AND VALUE OF TREE PLANTING.

Reports from all parts of the country show that the past season has undoubtedly been characterized by a more extensive planting of forest trees than any previous year in the history of the United States. The work is progressing very favorably in every State in the Union. It has been most extensive in California, in the great Middle West, and in the New England States. But even in the South, where planting has been more or less limited because of existing natural forests, the scope of the work has greatly broadened.

The trees planted have been mainly hardwoods. Several large nurserymen, however, report greater sales of conifers for forest planting than they have ever made before. In the Middle West, catalpa, black locust, Osage orange, and Russian mulberry were the favorite trees; in the North and Northeast preference was given to white pine, chestnut, larch, and spruce; in the South the native conifers held the lead; and in California, where the immense annual planting area has been increased to at least five times its former size, eucalyptus had practically a monopoly.

A few figures readily show the value of forest planting from a commercial standpoint. In Pawnee County, Neb., a 16-year-old catalpa plantation gave a net return of $152.17 per acre at the time the plantation was cut. This meant an annual profit of $6.24 per acre. A 10-year-old plantation of the same species in Kansas showed a net value of $197.55 per acre. Still another plantation, in Nebraska, gave a net income of $170.50 per acre when 14 years old, which amounts to an annual income of $8.69 per acre. Several equally striking cases could be cited throughout the entire Middle West, and it is known that where the catalpa will succeed no other tree will pay so well. Good soil and moisture conditions are, however, essential for success with this tree.

Osage orange has been known to produce as high as 2,640 first-class posts and 2,272 second-class posts per acre, and it is well understood that no posts are better than those of Osage oranges. Land producing such a forest as this could hardly be put to a better use, since timber is the easiest of all crops to raise and from now on will never go begging for a market.

Red cedar in plantations 25 years old has reached a value of $200.54 per acre. European larch used for fence posts or telephone posts reaches an average value of $200 to $300. White

pine plantations 40 years old have exceeded a value of $300 per acre, and it is known that the eucalyptus, even when grown for fuel alone, can compete as to profits with oranges.

It does not take a lifetime to get results. Catalpa often reaches a post size in from eight to ten years, and will give service as a post for from fifteen to forty years. Osage orange, which reaches post size in from twelve to fifteen years, usually lasts longer than catalpa. Black locust, though badly affected by the borer in some regions, grows about as fast as the catalpa and has almost the same post value, while it has the great advantage over catalpa of being able to thrive on poor land. European larch reaches a size suitable for telephone poles in twenty-five years. When treated with preservative it will then last from fifteen to twenty-five years. Eucalyptus makes a heavy yield of fuel in seven years, and the crop should nearly always be cut before ten years. On favorable sites white pine will make saw timber in from forty to sixty years. Already the demand for the timber of this tree shows conclusively that the investment will prove immensely profitable.

In every region of the United States there is at least one forest tree, and generally there are several forest trees, which can be planted with a complete assurance of commercial success if the plantation is properly established and given proper care. The Government has made a very careful study of most of the forest plantations in the United States. Its publications on tree planting may be had free of charge upon application to the Forest Service, U. S. Department of Agriculture, Washington, D. C. The studies on which they were based were made especially for the benefit of farmers and other land owners, and to prevent the waste of thousands of dollars annually lost by planting the wrong forest trees or by improper care of plantations.

From the manner in which our natural timber has been cut it is clear that each region will have to be made as nearly self-supporting in timber growth as possible. The lesson of the past is that the right forest trees grown in the right way will bring a big profit.—*U. S. Department of Agriculture, Forest Service.*

THE MERITS OF THE FRUIT FLY.

By Frank E. Lutz,

Cold Spring Harbor, N. Y.

The common, small, red-eyed "fruit fly" (*Drosophila ampelophila*) is most excellent laboratory material. Feeling that too few teachers of biology appreciate this fact I wish to call attention to some of its merits.

Living insect material is often difficult to get in the winter, and yet nearly all teachers would be glad to illustrate a number of life history points with live things. The fruit fly—known as "sour fly," "vinegar fly," and "pomace fly"—can be found at almost any time in any fruit store or about vinegar or pickle barrels. However, the easiest way to get it is to leave a ripe banana, partly peeled, in an exposed place during the summer or autumn. It will probably be full of larvæ in a few days. If it be then put in a battery jar covered with cheese cloth, the work of getting the stock is completed. To keep the stock in good condition one needs only to add a fresh banana every two or three weeks and occasionally take out the very old ones.

At normal room temperature the eggs hatch in two or three days. The larvæ feed for about a week. The pupal period is about four days long. The adults start to lay eggs the second day after emergence and continue for nearly a month. It will thus be seen that we have here ideal material for illustrating complete metamorphosis. All four stages can be had in the short space of two weeks. Each student can easily rear the flies for himself in a large vial or a small bottle.

The adults are perfect slaves to light and can always be depended upon to illustrate positive phototactism. They do not go back on one at the critical moment. This reaction may be used in transferring adults from one bottle to another or in opening bottles to take out larvæ or pupæ. If the mouth of the bottle be kept away from the light practically no flies will escape during the operation. They are also slightly negatively geotactic.

The influence of the environment upon the life cycle may be illustrated by starting three batches of eggs at the same time. If one be kept near a steam radiator, or other heater, a second in the middle of the room, and the third at a window a most surprising difference in the rate of development will be noted.

Sexual dimorphism and dichromatism can both be seen without

magnification or more easily by aid of a low power lens. The males are smaller than the females. They also are distinguished from females in having the posterior-ventral part of the abdomen pigmented. There is a difference in the sexes in the duration of the embryonic stages. More interesting still but somewhat difficult to see, the males have on their front legs relatively immense "sex combs."

The chief drawback of Drosophila is its small size, but large size and short generations are incompatible. Moreover the training involved in handling small things is of itself valuable.

THERMOMETRIC CONVERSION.

By Hilton Ira Jones,

Lawrence Scientific School.

As a teacher of high school Physics, I labored faithfully to impress permanently on the mind that the two familiar formulæ $C = 5/9\ (F - 32)$ and $F = 9/5\ C + 32$ in such wise that they would always be at fingers' end for use. My failure I attributed to faulty methods. Since my connection with the Lawrence Scientific School at Harvard, I have noticed that not over fifty per cent of the men passing the entrance examinations can correctly use the formulæ and not one man in ten among the advanced students can apply them quickly, although most of them can figure them out. I find they, like my students, are forever in doubt whether to add, or subtract, the thirty-two degrees before or after multiplying.

In my high school teaching I once merely suggested a method, which so far as I know is original, and found a year after that most of the students were working their conversion problems by that method, which I had mentioned but once.

Most people are aware that forty below zero Fahrenheit is the same as forty below in Centigrade. If then we simply add forty to whichever reading we wish to convert we have it at common zero, so to speak, then we multiply by five ninths or nine fifths as the case may be and again subtract the forty to get it to zero reading. Thus:

$68°\ F + 40° = 108° \times 5/9 = 60° - 40° = 20°$ and

$60°\ C + 40° = 100° \times 9/5 = 180° - 40° = 120°\ F.$

The method is not any shorter but the virtue of it is that when the attention is called to the facts once the student will remember them indefinitely. I submit it for what it is worth.

PRELIMINARY REPORT OF THE COMMITTEE OF THE CENTRAL ASSOCIATION ON ALGEBRA IN THE SECONDARY SCHOOLS.

The work in high-school algebra should consist of an elementary course given the first year and a more advanced course given not earlier than the third year, after demonstrational geometry.

The First Year Course.

The purpose of the first year course should be to train pupils in the solution of problems by means of the equation, rather than to exercise them in abstract manipulation. It should be concrete rather than demonstrational. The topics treated and the order and manner of treatment should be such as best to serve the purpose of the first year's work. It is not to be implied that any necessary drill should be omitted.

The Later Course.

The later course, covering at least one-half year, should include the demonstrational work and all topics usually given in elementary algebra. The kind of manipulations necessary for advanced work in mathematics is best emphasized in this course. A review of the topics treated in the first year is essential, but the point of view is different.

This course should in no case be given until after demonstrational geometry. The practice, all too common, of completing high-school algebra in fifteen consecutive months, cannot be too strongly deplored. Geometry is concrete. The pupil's introduction to formal proof should be through concrete relations. Moreover the maturity of mind necessary for this algebraic work is not generally attained before the third year.

Topics to be Omitted from First Year's Work.

The following topics have little or no relation to the first year's work and might be omitted:

1. Complicated brackets.
2. H. C. D. and L. C. M. by division.
3. Remainder theorem.
4. Complicated complex fractions.
5. Simultaneous equations in more than three unknowns.

6. Binomial theorem.

7. Cube root of polynomials.

8. Formal study of the theory of exponents.

9. Extended study and manipulation of radicals and imaginaries.

10. Equations containing complicated radicals.

11. Simultaneous quadratics except one linear and one quadratic.

12. Theory of quadratics.

The object of omitting these topics is not to make the course easier but rather to give the course unity and to gain time for the introduction of problems. With these topics omitted, the course affords all the intellectual training that mathematics is supposed to give. The manipulations involved in the above omissions are those that are performed with the least intelligence by first year pupils. Operations performed mechanically give little training in thought and little power while the solution of problems affords the best possible training.

Order of Topics in the First Year's Work.

The traditional order of topics has no relation whatever to the purpose of the first year's work, and careful study fails to reveal any reason for clinging to it. Each teacher and author must use that order which most strongly appeals to him. The committee does not wish to dictate an order, but merely to emphasize fundamental principles which must be taken into consideration in rearranging topics. The object in this change of order is not to teach the easier topics first, but rather to throw emphasis upon thought and upon those manipulations and their applications which will be required for immediate use by all pupils in elementary science courses, by teachers of elementary schools who are educated largely in our high-schools, and by men interested in mechanical pursuits.

The following order of development of topics is suggested:

a. Addition problems; equations; abstract addition.

b. Subtraction, transposition in equations; numerical equations; simultaneous equations (simple); elimination by addition and subtraction; abstract subtraction; simple brackets.

c. Multiplication and division taught together; complicated problems in long division may be deferred till later; equations involving multiplication; easy fractions (monomial denominators); fractional equations; easy involutions; simultaneous equations (other methods of elimination).

d. Special cases of multiplication with easy factoring.

e. Solution of quadratics by factoring.

f. Roots and radicals.

g. Pure quadratics; affected quadratics by completing the square; simultaneous equations involving one quadratic and one linear.

h. Multiples and common divisors by the factoring method; addition and subtraction of fractions.

i. Multiplication and division of fractions; easy complex fractions.

j. Harder fractional equations; verification of roots.

The following points in the relation of topics should be carefully noted:

1. If judicious use is made of the pupil's knowledge of numerical fractions, algebraic fractions with numerical denominators may be introduced from the first.

2. Transposition of the terms in an equation involves only addition and subtraction and may be taught with these topics.

3. Elimination by substitution and the solution of fractional equations with numerical denominators, are possible as soon as the pupil understands the simple bracket and the multiplication of a polynomial by a monomial.

4. Multiplication of powers beyond the first, when bases are alike, and long division, are rarely, if ever, needed in first year problems.

5. Special square roots and simple quadratic equations are possible as soon as the pupil can write $(a+b)^2$ and $(a-b)^2$. A series of exercises like the following forms an interesting introduction:

a. Squares of the type $(a+b)^2$ and $(a-b)^2$.

b. Square roots of such expressions as $a^2+2ab+b^2$.

c. Supplying missing terms in squares,

$$9a^2+?+25b^2=(?\quad)^2$$
$$4a^2+28ab+?=(?\quad)^2$$

d. Squares of type $(a—b—c—d)^2$, $(a—b—c)^2$, and $a+b+c)^2$. By use of brackets these can be referred to types $(a+b)^2$ and $(a—b)^2$.

Square roots of such expressions as:
$(a+b)^2+2c(a+b)+c^2$ and $a^2+b^2c^2$
$+2ab+2bc+2ac$.

6. Quadratics may be introduced as soon as square roots are known.

7. The solution of a pair of equations in two unknowns in which one equation is quadratic and one linear may be given immediately after quadratics.

8. Long multiplication and division are interesting when taught together. In general, square roots of polynomials should not be attempted before the pupil is somewhat experienced in the division of polynomials. Most pupils have had square roots of numbers in the grammar grades.

9. Special cases of multiplication and factoring should be taught together.

10. The solution of quadratic and higher equations can be taught with factoring.

11. If factoring is separated very far from fractions and harder fractional equations, little or no immediate use can be made of some important cases of factoring.

12. Certain calculations in mensuration furnish excellent illustrations of the value of elementary manipulation of radicals.

13. It will be seen, therefore, that most of the different kinds of equations suitable for the first year may be taught before fractions, before factoring, before long division, even before multiplication of powers of like bases. This early introduction of simultaneous and quadratic equations increases vastly the scope and variety of the problems that can be given.

The Connection Between Arithmetic and Algebra.

This connection should be as close as possible. The following are suggestions:

1. An algebraic principle should grow out of the pupil's knowledge of known numbers.

2. Every algebraic principle used may be verified by repeated references to known numbers. (See discussion of algebraic notation elsewhere.)

3. Problems from arithmetic may be solved by algebra. (See discussion of problems elsewhere).

The following results should be aimed at:

1. Pupils should appreciate that algebraic symbols deal with numbers and numbers only.

2. Algebraic principles should be made to appear reasonable to pupils who are too young to appreciate formal abstract proofs.

3. Pupils should be taught to test accuracy of work and validity of processes employed. For example, is $a/b=a^2/b^2$? (a frequent mistake.)

The Meaning and use of Algebraic Notation.

The following suggestions are valuable in bringing about an intelligent comprehension of algebraic notation:

1. The constant correct use of technical terms by both teachers and pupils.

2. Daily questions on notation.

   a. What is $(a+b)$, or what does $(a+b)$ represent? Ans. The sum of two numbers.

   b. What is the coefficient of x in axy?

   c. Why is $a(x+y)-b(x+y)$ not factored? Ans. It is in the form of a difference and not of a product.

3. The constant use of Arabic numerals in place of letters in algebraic expressions. Ex. $a(b-c)=ab-ac$; $7(9-2)=63-14$.

4. Daily evaluation of algebraic expressions, and verification of all abstract manipulations with known numbers. This brings home as nothing else can the real meaning of a form.

5. Constant translations into algebraic notation of expressions stated in words.

   Ex. If a and b represent any two numbers, write their sum.

6. Constant translation of algebraic expressions into English.

7. Problems involving number relations. Ex. Twice a certain number increased by 4 is equal to the number increased by 15. Find the number.

8. The translation of equations into problems and number relations. The equations so used must be short so that the pupils can form good English sentences. Ex. $5(x+2)-4=x+14$. If 4 be subtracted from 5 times the sum of a certain number and 2, the result is 14 more than the number.

9. Solution of all equations should be verified. Equations giving unwieldy results should be used sparingly.

10. Pupils should be carefully taught the order in which operations are to be performed when an expression involves a

series of operations. Ex. $14+4(8+4)\div(32-20)$. This is a matter of great importance and pupils are generally ignorant of it.

Treatment of Negative Numbers.

1. The nature and use of negative numbers should be carefully discussed from concrete illustrations.

Ex. Latitude and longitude; temperature; bank deposits and withdrawals; gains and losses; opposing forces.

2. Abstract computations with negative numbers should be accompanied by concrete problems involving the above subjects.

3. Some problems should give negative results and the interpretation should be required.

Problems.

Problems should be practical and valuable and should come within the scope of the pupil's experience. They must be abundant and, as far as possible, must be introduced with each topic studied.

The lists of problems given in many texts are little better than sets of puzzles. The question of how to train classes to solve problems is difficult and serious. There are two reasons for this:

First. Until recently no attempt at a classification has been made beyond one that depends upon the nature of the equation produced. If any type of problem, as velocity or distance problems, is worth introducing, the entire class should be taught to handle that particular type. This is impossible if only miscellaneous lists are given.

Second. Even where there is some attempt at classification according to subject matter, there is little or no gradation among the problems of any one kind and frequently only a few of the hardest of each type appear.

To remedy this, problems should be classified according to subject matter and lists should be very carefully selected and graded. Many valuable problems are based on formulae from physics or mensuration. It is particularly necessary that such problems be carefully graded beginning with the very simplest and that elementary conditions be clearly comprehended. Lists thus classified should be followed by miscellaneous problems.

General Treatment of Problems.

For each particular formula that is introduced the following treatment is recommended.

I. A clear, concise statement of the law to be used with whatever explanation is necessary to make it appear reasonable.

a. Most of the laws of mensuration are familiar to pupils and little discussion is needed beyond a translation of the formula.

b. The laws of physics usually need explanation. For example, the law of the levers. A discussion of the teeter forms a good beginning. The law may soon be stated in words and then by use of suitable symbols be translated into an algebraic formula. Thus $w_1/w_2=d_2/d_1$, or in words the ratio of the weights equals the inverse ratio of the distances.

II. Evaluation of the formula for arbitrary values of the constants and solution of the resulting numerical equation. Ex. Find d_2, if $w_1=5$, $w_2=3$, $d_1=12$.

III. Solution of the formula as a general equation, for each of the constants involved.

IV. Solution of a set of carefully graded numerical problems involving the use of the formula.

V. Solution of general problems.

Arithmetic as a Source of Algebraic Problems.

The common formulae in interest and percentage form the basis for many good problems in algebra. Before introducing such problems the previous training of pupils should be ascertained with considerable care. A large per cent of difficulties encountered are due to failures in this particular. If pupils have been taught to solve interest by the formula $i=ptr$, there is no difficulty. In many schools they are required to analyze each case presented and no formal statement of rule or method has been allowed. If such pupils are presented with the interest formula and required to solve problems by it, confusion results and the work immediately becomes mechanical. Each teacher must adapt his methods to the previous training of his class and, if necessary, develop the formula after developing special cases.

Geometry a Source of Algebra Problems.

The following mensuration problems may each be treated according to the outline given above.

1. Area of rectangles, $s=ab$.
2. Area of triangles, $s=\frac{1}{2}ab$.
3. Area of trapezoids, $s=\frac{1}{2}a(b_1+b_2)$.
4. Volume of rectangular solids, $v=lwd$.
5. Volume of pyramids, $v=1/3\ lwd$.
6. Sides of a right triangle, $a^2+b^2=h^2$.

Problems based on these formulæ may give rise to either simple or quadratic equations in either one or two unknowns.

Physics as a Source of Algebra Problems.

Much care is needed in the introduction of physics problems into the first year's work, at least so long as our present arrangement of courses in science and mathematics remain as they are. Good teaching requires that each subject be pushed out into its universal relations to as great an extent as can be grasped by the pupil, and as time permits. This requires that we teach the same kind of manipulations and equations as are likely to occur in subsequent work. But it does not require that we teach physics. Whenever physics problems are introduced it should be solely for the mathematical content. Pupils should not, therefore, be required to prove or discover any of the laws that they may need to use. All such laws must be made to appear reasonable to pupils and only those should be introduced which appeal to them readily through a clear and concise statement.

The following formulae from physics may be used as a basis for algebra problems. The outline given above can be followed:

1. Uniform motion. $d=vt$.
2. Resultant of forces acting in a straight line, $r=a+b$.
   $r=a-b$.
3. Uniform acceleration, $s=vt+\frac{1}{2}at^2$, $s=vt-\frac{1}{2}at^2$,
   $s=\frac{1}{2}\ gt^2$, $v=u+at$.
4. Specific gravity $s=w/w'$, $w'=w/s$.
   w=weight of given substance,
   w'=weight of an equal volume of water.
5. Density, $d=w/v$; w=weight of substance in grams,
   v=volume of substance in cu. cm.
6. Momentum=velocity×weight. It is a measure of the force with which one body strikes another. When one body

strikes another at rest or moving in the same direction, the sum of the momenta before impact equals the combined momentum after impact. If the bodies are moving in opposite directions, the combined momentum after impact equals the difference between the momenta before impact.

7. For levers, $wd=w'd'$, or $w/w'=d'/d$. Translate as suggested under discussion of ratio.

8. Laws for pendulum $\sqrt{l}/\sqrt{l}=t/t'$. $\sqrt{l}/\sqrt{l}=n'/n$.

9. Horse power=number of lbs.×number of ft./550×number of sec.

Velocity and distance problems usually give more trouble than most other kinds. In these and with all physics problems, the various cases should be carefully isolated, and each one dwelt upon through simple numerical cases until the pupils grasp the situation, and this should be done repeatedly before the formula is used.

Graphs.

The graph as a picture of the relation between data is of growing importance. But it is a means and not an end as some seem to think it.

The pupil can be started in such work by causing him to make graphic representations of a series of numbers unrelated by any known law. Temperature curves, population curves and curves of rainfall can be given him early in his experience. In many places this is being done in the grades in connection with nature studies. This should be followed by graphs of data whose law is expressible. If the pupil makes a table of numbers whose sum is 8 and plots those numbers, he secures a graphic representation of a condition which he expresses as $x+y=8$. In a like manner he can make graphs for problems that have to do with the price of commodities, interest, travel, etc. By the time he has reached simultaneous equations he is familiar with the graph and has a good conception of what such equations mean. The analytical solutions then have a definite meaning. Too often we give the analytical solutions and the graphic representation afterwards. The light is turned on after the pupil has worked awhile in darkness. It would seem best to turn on the light first.

It is difficult to set limitations on the use of graphs. In general the graph has fulfilled its purpose when it has made clear

the point in question. Anything beyond this is apt to be superfluous. In the later course there is great danger of carrying the work further into analytical geometry than is desirable. It is doubtful if anything more than the circle and parabola should be used. Even with these the simplest form of the equations should be given.

The extent to which graphs should be given in any phase of algebra must be determined by the teacher, just as the extent to which any other device used for clarifying the work is determined by him.

Radicals and Exponents.

Radicals and exponents should be treated together. There is no value in treating these subjects separately, as is usually done. This work belongs mainly to the later course, very little finding a place in the first year. Only the simpler cases should be given. The manipulation of some of the common forms involving square root are important. This should not extend beyond the rationalization of fractions with monomial denominators. In the later course the forms should not be more involved than those found in the rationalization of fractions having binomial denominations. Radical equations should not be given in the elementary course.

Instead of further work in the calculus of radicals some concrete problems from elementary mensuration should be given in the first year course.

1. The computation of the hypotenuse of the right triangle when the sides are known. Enough of this should be given to make the class appreciate that $\sqrt{a}+\sqrt{b}$ is not $\sqrt{a+b}$.

2. The computation of the diagonal of the square. Enough of this should be done to make the class appreciate the occurrence of $\sqrt{2}$.

3. Altitudes and areas of equilateral triangles, bringing out the occurrence of $\sqrt{3}$.

4. The area of regular hexagons, inscribed and circumscribed squares and others.

5. Problems involving the pendulum formulæ might be introduced here, if properly treated. See the outline treatment elsewhere.

Ratio and Proportion.

This topic has a place in the first year for two reasons: First, a large per cent of problems that are likely to be met in school and out are in reality problems in proportion. Secondly, an elementary knowledge of proportion is essential as a preparation for geometry, which should follow in ithe second year.

The fractional form should be used for all proportions. It is the sensible form. As evidence of this, attention might be called to the proofs of the important properties of proportions. It is the form which keeps before the child the true nature of the proportion, an equality of ratios.

Suggested Details for the Later Course.

This course should be designed for students who are preparing for college or technical schools. It will also attract others who have a special aptitude for mathematics. It should not be required of all students.

1. Review of the fundamental operations; manipulation of signs; simple equations; and simultaneous equations.

2. Formal statement and demonstration of the theorems of elementary algebra. No attempt should be made to reduce the number of assumptions to a minimum. Problems involving positive integral exponents; binomial theorem; factoring, which should include the cases omitted in the first year; remainder theorem; solution of quadratic equations by factoring, by completing the square and by the formula; theory of quadratics; simultaneous quadratics; fractions and fractional equations; theory of exponents; radicals and imaginaries—perform manipulations by reducing to fractional exponents; radical equations; progressions; drill for power and speed. Concrete problems throughout.

Recommendations for a Higher Course.

The "later course" described above should normally occupy a half year. For the strongest high schools which give two years to algebra, for the better academies, for normal schools and for subfreshman work in small colleges, a somewhat stronger course is recommended.

This course should contain a complete treatment of what is ordinarily known as secondary algebra, but from a decidedly more mature point of view than is proposed in the first and second courses. The treatment should be deductive in character,

the argumentation being as carefully worked out as it is at present in geometry. This course should contain a fuller treatment of some topics included in the above list; thus the chapters on systems of linear equations should contain the elementary treatment and use of determinants as high as the fourth order. The chapter on radicals should contain a somewhat full discussion of irrational numbers, etc. Other topics should be included, for example, the approximate solution of simple numerical equations of the third and fourth degrees, with applications to problems in geometry and physics.

The Simultaneous Teaching of Arithmetic, Algebra and Geometry.

The above report has been limited to the topics that should be taught and the order of their presentation. Little or nothing has been said about the method of presentation. The committee has purposely avoided this, realizing that it would open a subject too broad to be treated fully in connection with that on subject matter. It is not out of place, however, to make the following suggestion which shows what is being done in some of our schools and which we believe will be more generally used in the future.

To bring the different branches of mathematics into closer relation and to preserve the unity of mathematical work is so much to be desired in secondary schools that the simultaneous teaching of arithmetic, algebra and geometry would seem indispensable.

By this is not meant that so many hours per week be devoted to one subject and the remaining hours to another—not parallel teaching—but the actual blending of the subjects wherever the relations are so close that such a blending will not be forced. During the first year's work almost no attempt should be made at demonstrational geometry, but a large amount of constructional and mensurational geometry can be introduced in connection with problems throughout the year, and thus greatly enrich the algebra on the concrete side while in no way weakening the development of the subject as algebra.

Any criticisms or suggestions will be carefully considered by the committee in connection with the presentation report at this Thanksgiving meeting in St. Louis.

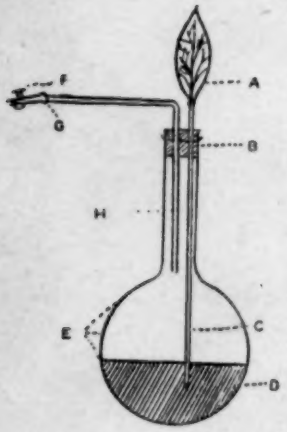
Charles Ammerman, Chairman, McKinley High School, St. Louis.
Ira Condit, Iowa State Normal School, Cedar Falls, Ia.
Elizabeth McConnel, Shortridge High School, Indianapolis, Ind.
C. W. Newhall, Shattuck School, Faribault, Minn.
Mabel Sykes, South Chicago High School, Chicago, Ill.

DEMONSTRATION OF STOMATA IN LEAVES.

The following notes were prepared for publication in the *School World* by two English teachers of botany. Doubtless some of our readers have devised even better experiments for this particular demonstration. If so, we shall be glad to have brief notes together with diagrams for publication.

Experiments to Show the Existence of Openings on Leaves.

The following experiment, which I have used for showing that the external coating of a leaf must be pierced by openings, may be of interest to some of your readers. The apparatus is shown in the accompanying figure. The leaf (A), which must be quite undamaged, is sealed by its petiole into a piece of glass tubing (C) drawn out to a fairly fine point and dipping into water (D) contained in the flask. Through the two-holed rubber stopper (B) passes the tube (C), and a second piece of tubing (H) bent at right angles, fitted with a piece of rubber tubing (G) and clip (F). On exhausting the air above the water, a stream of bubbles rises from the end of the tube C to the surface of the water. By continuing the process of exhaustion, the stream of bubbles may be produced indefinitely, and hence, since all the joints of the apparatus are *air-tight*, the experiment shows that there *must* be openings in the surface of the leaf. Further, on fastening the clip, the size of the air bubbles which still appear gradually diminishes, until finally the bubbles themselves disappear. The explanation of the latter part of the experiment is a useful exercise on pressures.

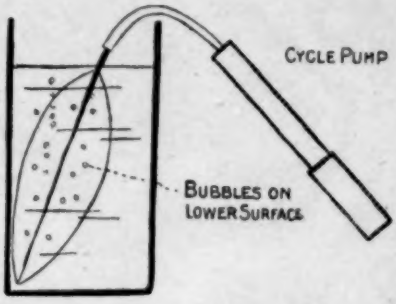


The County School, Barry, Glam. E. H. DAVIES.

In your last issue Mr. E. H. Davies described one method of demonstrating leaf-stomates; I should like to describe another demonstration, both simple and effective, which I have found

useful, and which may be of use to teachers who have a limited supply of apparatus at their disposal.

A large leaf, a short piece of rubber tubing, a cycle pump, and a suitable vessel of water large enough to submerge the entire leaf are necessary. We find that a Ficus leaf (india rubber plant) is suitable, and its large petiole can without difficulty be firmly fixed into one end of the rubber tubing, whilst to the other end of the tubing the cycle pump is attached (see Fig.). When the leaf is submerged and the pump in action, a large number of bubbles arise from the *under surface* of the leaf and none from the upper surface. The bubbles arise from the stomates which are present on the under surface in this type of leaf.



From this experiment it is evident that the bubbles pass out through natural openings (stomates) in the leafskin, and there is no need for the assumption required by Mr. Davies's experiment, that, because all the joints of the apparatus are air-tight, therefore the air must come through leaf-openings.

Another advantage of this method is that it shows the distribution of the leaf-stomates.

The University, Leeds. ERNEST E. UNWIN.

PRODUCTION OF CHROMITE IN 1906.

Chromite, or chromic iron ore, is used in making ferrochrome alloys and, in combination with nickel, for hardening steel for armor plates, as well as for the manufacture of chromium salts for pigments, and for other purposes.

The only active chromite mines in the United States are in California, where two mines furnish a small product (valued at $1,800 in 1906) which is used in the crude state for lining copper furnaces. As over half a million dollars worth of chromium in different forms was imported into the United States in 1906, it would seem that some of the numerous chromite deposits in this country might be profitably exploited.—*U. S. Geol. Survey Bulletin No. 298.*

PROBLEM DEPARTMENT.

IRA M. DELONG,

University of Colorado, Boulder, Colo.

Readers of the Magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to Ira M. DeLong, Boulder, Colo.

Algebra.

67. *Proposed by H. E. Trefethen, Kent's Hill, Maine.*

Solve for x and y the equations

$$x+\frac{x^2}{y}+y=a \qquad (1)$$

$$x^2+\frac{x^4}{y^2}+y^2=b \qquad (2)$$

Solution by I. E. Kline, Blairstown, N. J.

Factor (2) $\left(\frac{x^2}{y}+y+x\right)\left(\frac{x^2}{y}+y-x\right)=b \qquad (3)$

Divide (3) by (1) $\frac{x^2}{y}+y-x=\frac{b}{a} \qquad (4)$

Subtract (4) from (1) $2x=a-\frac{b}{a}$, $x=\frac{a^2-b}{2a}$.

Add (4) and (1) $\frac{2x^2}{y}+2y=a+\frac{b}{a} \qquad (5)$

Substitute in (5) the value found for x

$$2\left(\frac{a^2-b}{2a}\right)+2y^2=ay+\frac{b}{a}y, \text{ whence } y=\frac{a^2+b\pm\sqrt{(3a^2-b)(3b-a^2)}}{4a}$$

68. *Proposed by R. Boyle, Portland, Oregon.*

An army column is 25 miles long and is marched 25 miles. At the same time that the column started to march a courier started and rode forward to the head of the army, then immediately returned to the rear when he found that the rear was occupying the same ground as that occupied by the head of the army at the beginning of the march. Find how many miles the courier traveled.

Solution by W. T. Brewer, Quincy, Ill.

Let x = distance that the army marches before the courier arrives at the head; then while the army marches x miles the courier rides $x + 25$ miles. While the army marches 25 miles, the courier rides $2x + 25$ miles. Hence $x + 25 : x = 2x + 25 : 25$. Therefore, $x = 17.6776$ miles, and the courier travels in all $2x + 25 = 60.3553$ miles.

Geometry.

69. *Proposed by H. H. Wright, New York, N. Y.*

Two triangles are equal if the base, the opposite angle and its bisec-

tor of one are respectively equal to the base, opposite angle and its bisector of the other.

Solution by proposer.

In triangles ABC and A'B'C' let AC = A'C', angle B = B', bisector BE = B'E'. Circumscribe a circle about each triangle, denote their centers by O and O'; produce BE, B'E' to meet the circles in D, D' and let F, F' be the mid points of AC, A'C'.

Angle FAO = F'A'O' being complements of B and B'; AF = A'F'; therefore triangle AFO = A'F'O', and the two circles having equal radii, OA, O'A' are equal.

Since AC = A'C', arc AC = arc A'C' and arc AD = arc A'D', chord AD = chord A'D'. In the similar triangles AED, ABD,

BD : AD = AD : ED; and $\overline{AD}^2$ = BD . ED; in like manner $A'D'^2$ = B'D' . E'D'. Hence (BE + ED) ED = (B'D' + E'D') E'D':

substituting BE for B'E' and transposing, $\overline{ED}^2 - \overline{E'D'}^2$ + BE (ED — E'D') = 0 so that ED = E'D'; and BD = B'D', arc BAD = arc B'A'D'. Since AD = A'D' arc AB = arc A'B' and chord AB = chord A'B'. Similarly BC = B'C'.

Therefore the three sides of one triangle are equal respectively to the three sides of the other triangle.

70. *Proposed by I. E. Kline, Blairstown, N. J.*

A horse is tied to a stake at the edge of a circular pond. The radius of the pond is 200 ft. and has no fence around it. How long must be the rope so that the horse may graze over one acre?

Solution by H. C. Whitaker, Ph.D., Philadelphia, Pa.

Denote the given radius (200 ft.) by r, the required length of rope by x, the radian measure of the arc of the pond reached by the horse by 2θ. The portion of the pond which the tied horse could cover by swimming consists of two circular segments, one of radius r, central angle 2θ and area $\frac{r^2}{2}(2\theta - \sin 2\theta)$; the other of radius x, central angle $\pi - \theta$, and area $\frac{x^2}{2}(\pi - \theta - \sin \theta)$. The sum of these two segments is equal to $x^2 - 43560$.

From the geometry of the figure $x = 2r \sin \frac{\theta}{2}$ whence $x^2 = 2r^2(1 - \cos \theta)$.

Also $\sin 2\theta = 2 \sin \theta \cos \theta$. Substituting and reducing

$$(\pi + \theta) \cos \theta - \sin \theta - 2.05259 = 0$$

whence $\theta = 45°21'.1$ and $x = 154.207$ ft.

71. *Proposed by E. L. Brown, M.A., Denver, Colo.*

From the vertices of a triangular field whose sides are a, b, c, the angles of elevation to the top of a perpendicular tower are observed to be α, β, γ respectively. Required the height of the tower.

Solution by H. C. Whitaker, Ph.D., Philadelphia, Pa.

The distances from the vertices of the triangle to the foot of the tower are $x \cot\alpha$, $x \cot\beta$, $x \cot\gamma$, respectively. Hence the three equations, θ being at the tower opposite c and φ opposite a:

$$x^2\cot^2\alpha+x^2\cot^2\beta-2x^2\cot\alpha\cot\beta\cos\Theta=c^2$$
$$x^2\cot^2\beta+x^2\cot^2\gamma-2x^2\cot\beta\cot\gamma\cos\varphi=a^2$$
$$x^2\cot^2\gamma+x^2\cot^2\alpha-2x^2\cot\gamma\cot\alpha\cos(\Theta+\varphi)=b^2$$

For the numerical values of the sides and the angles of elevations, these three equations can be solved for x, Θ and φ.

The equation in x will be of the fourth degree in x^2, that is, the eighth degree in x.

Credit for Solutions Received.

Algebra 62. W. T. Brewer, Frank Heinaman.

Algebra 67. W. T. Brewer, H. C. Whitaker, Frank Heinaman, I. E. Kline, I. L. Winckler, H. E. Trefethen, Rachel E. Mentzer, J. C. Boulden.

Algebra 68. H. C. Whitaker, W. T. Brewer, R. Boyle, I. L. Winckler, H. E. Trefethen, F. M. Phillips.

Geometry 64. J. W. Ellison.

Geometry 69. H. C. Whitaker, H. H. Wright, I. L. Winckler, H. E. Trefethen.

Geometry 70. I. E. Kline, H. C. Whitaker, H. E. Trefethen, I. L. Winckler. One incorrect solution was received.

Trigonometry 71. H. C. Whitaker. One incorrect solution was received.

Applied mathematics 66. Philip Fitch.

Total number of solutions, 29.

PROBLEMS FOR SOLUTION.

Algebra.

77. *Proposed by I. L. Winckler, Cleveland, Ohio.*

I bought 674,867 sheep at less than \$10 per head; I paid for them in ten-dollar bills and received back in change \$7.39. How many bills did I give? (Mathematical Magazine, 1883).

78. *Proposed by W. T. Brewer, Quincy, Ill.*

Find the values of x and y in the equations:

$$\sqrt{\left(x+y-\frac{1}{x+y}\right)}-\sqrt{\left(1-\frac{1}{x+y}\right)}=\frac{x+y-1}{x+y} \qquad (1)$$

$$x-y=3+\frac{2}{\sqrt{x-y}} \qquad (2)$$

Geometry

79. *Proposed by D. C. Colson, Tipton, Ga.*

Given two circles with centers O and O′ and a point A in their plane, to draw through the point A a straight line meeting the circumference at B and C so that AB : AC = m : n. (Wentworth's Plane Geometry, page 179, Ex. 311.)

80. *Proposed by H. E. Trefethen, Kent's Hill, Maine.*

If from any point within or without the plane of a given rectangle

lines be drawn to the vertices of the rectangle, the sum of the squares of the lines drawn to two opposite vertices is equal to the sum of the squares of the lines drawn to the other two vertices.

Applied Mathematics.

81. *Proposed by William B. Borgers, A.B., Grand Rapids, Mich.*

Assuming 0.5 as the coefficient of friction between the tires and the pavements, 1.25 as the factor of safety, and $g = 32$ ft. / sec.^{2}, what is the highest velocity at which a bicycle could turn a curve of radius 100 ft.? (The ground is assumed level.)

DEPARTMENT OF METROLOGY.

The British Metric Defeat.

The English House of Commons consists of 670 members. Of this number 414 had voluntarily pledged their support to the metric bill before that body last winter. This bill was called up for a second reading and discussion March 22, 1907. Two hundred and fifty-six members were either undecided or opposed. After some very absurd and humorous speaking in opposition, a vote showed 118 in favor and 150 opposed. Thus the measure was defeated, and thus only 118 pledges out of 414 were redeemed.

The defeat was said to have been due largely to the President of the Board of Trade, who made the ridiculous statement that the metric system had broken down hopelessly in France. It seems that a deputation of Lancashire cotton spinners and manufacturers had, at the psychological moment, visited the President and made him believe that France was about to turn back to the arpent and other measures in use before the French Revolution, or that the metric system had never been very generally used in France at all. The President expressed surprise at the opposition, but passed along the false statement.

While this defeat is temporarily unfortunate, there is still much encouragement. The people are getting educated in the metric system, and this in itself constitutes the certainty of its final triumph. In 1900 only 96 members were in favor of the metric system; to-day over 400 have shown their belief in it, though only a small number had the courage to vote against an eleventh hour misrepresentation to the Board of Trade's President. R. P. W.

Locomotives by Metric Measurements.

The recent construction of 20 locomotive engines on measurements of the metric system by the Baldwin Locomotive Works of Philadelphia, calls for more than passing notice, for it solves several problems. This contract, which was let in January last for $600,000, was to be completed in six months, the engines being for the Paris-Orleans R. R., France. "The firm bought metric standards, prepared metric gauges and templets, and every workman received a jointed metric rule graduated to millimeters." The superintendent of the Baldwin works,

Samuel M. Vauclain, states that the first impulse was to convert all the measurements into English units, but this was found to be impracticable, as there were 500 sheets of designs calling for over 10,000 different parts to each engine, and the type of locomotive called for demanded special accuracy of construction. Measurements on all shop drawings were put in millimeters, and no reference to the English system appeared anywhere. Superintendent Vauclain further says: "There is no greater difficulty in working to the metric system than to the English unit. In fact we find it somewhat easier, and our workmen are less liable to make mistakes in ordinary measuring. We experience no difficulty in using the two systems side by side."

Further: "I think the opposition to the metric system has been caused principally by inexperience. When once you have had experience in using various systems of measurements it is remarkable how little it is necessary to know of a system in order to get along satisfactorily with it in the workshops. The majority of the workmen do not know much more about the English measures than they do about any other system of measures. We could change to the metric system or we could use both systems without incurring any appreciable expense at the time. My opinion, however, is that, were we all using the metric system, it would be much more convenient to the workmen, and our errors would be appreciably less than they are at present."

From the standpoint of the workmen the following from a contemporary publication is interesting: "No more enthusiastic advocates of the universal metrology could be found than the 19,000 American workingmen concerned in the task. If the venerable English feet and inches were abolished to-day, the army of mechanics in the great shops in North Broad Street would hail the day. From a practical point of view they have come to recognize the infinite superiority of the standard of the meter over a scheme of measurement derived from mediæval inexactitude."

The successful completion of this contract seems to answer the two most important objections to a change to the metric system. 1. It proves that uneducated workmen can work to the metric system as easily as to the customary system, in fact they can do it with fewer errors and greater facility. 2. The introduction of the international system would not entail a prohibitive cost. This magnificent experiment has killed the bugbear. It should open the eyes of those who profess to see in the new system nothing but anarchy and financial ruin. Let manufacturers ponder this work and see whether the last of their objections are not answered. At least it should lead them to adopt the system for foreign contracts where metric measurements are in use. Over and over our consuls have dinged this necessity in our ears, but their counsel is commonly ignored, and the goods are "made in Germany."

R. P. W.

DEPARTMENT OF SCIENCE QUESTIONS.

FRANKLIN T. JONES,

University School, Cleveland, O.

This department is designed to serve as a medium for the exchange of ideas on questions and questioning in the sciences. Questions will be printed from various sources—college entrance examinations, text-books, etc., etc. Comment is invited. Suggestions and criticisms as to character, adaptability, and usefulness are desired. Readers of this journal are invited to propose questions and problems which will be of general interest, or of a type which will be useful in the class room. It is not expected that questions which will not be useful to pupils will be frequently printed.

Since the majority of the questions will be of a comparatively simple character, solutions and answers will not be published unless specifically asked for. Teaching suggestions are wanted.

Address all communications to the editor of the department.

Teachers will confer a great favor on the editor by sending copies of the final examinations used in their schools last June.

The June college entrance examinations in chemistry follow.

Teachers are invited to send in criticisms or commendations. For convenience the following outline is suggested:

(a) Are the questions of the right kind? Are they tests of memory or of attainment? Are they too general? too technical?

(b) Are the papers too difficult? too easy? Is the time allowed about right?

(c) Do the questions call for a knowledge of principles, or merely for text-book knowledge? Are they on fundamentals?

(d) Is a knowledge of more than can be taught in a single year of work required? What questions should not be asked?

(e) Are the papers fair to both teacher and pupil?

(f) Would science teaching be better if all pupils had to look forward to such tests given at the end of the year by some examining body not the teacher?

COLLEGE ENTRANCE EXAMINATION BOARD.

(Two hours)

In this examination 30 counts will be based on the laboratory note-book submitted by the candidate, and 70 counts on the following questions. Answer seven questions as indicated below:

A

Answer both questions in this group.

1. Answer three of the following:

(a) How does the total weight of the products of the combustion

of a burning candle compare with the total weight of the materials taking part in the combustion? Name and state the law which this illustrates.

(b) When hydrogen and oxygen unite, state the relation of the volume of steam produced to the volumes of hydrogen and oxygen used. State the law thus illustrated.

(c) A mixture of iron and sulphur is heated until they combine. State the chemical differences between the original mixture and the compound produced.

(d) Explain, in terms of the ionic theory, the changes which occur when an acid is neutralized by a base.

2. Complete four of the following equations, using formulas:

ferrous sulphide + hydrochloric acid =
calcium carbonate + nitric acid =
sulphurous acid + sodium hydroxide =
silver nitrate + potassium bromide =
ferric oxide + hydrogen =
phosphorus pentoxide + water =

Name, and give the formulas of, (a) five acids, (b) five bases, (c) five salts.

B

Answer two questions from this group.

3. How did you prepare hydrochloric acid in the laboratory? How did you ascertain three of its properties? How, in addition, could you show that this compound contains (*a*) hydrogen, (*b*) chlorine?

4. Give a chemical method of distinguishing between substances of the following pairs:

(*a*) sodium chloride and ammonium chloride.
(*b*) carbon dioxide and carbon monoxide.
(*c*) chlorine water and ammonia water.

Describe a method by which carbon dioxide may be converted into carbon monoxide.

5. Name in order of quantity four of the most abundant constituents of the atmosphere. How may the presence of any two of these be ascertained?

Which of the constituents of the atmosphere are of importance to animal life, and which to vegetable life?

Name some of the chemical results which might be expected if the atmosphere were composed entirely of oxygen.

C

Answer two questions from this group.

6. Name an important ore of lead. How would you proceed to get metallic lead into solution? Give the formula of the resulting compound of lead.

Name two alloys of copper in common use and their other constituents.

For what is metallic aluminum used, and upon which of its properties does such use depend?

7. Name two natural and two artificial modifications of the element carbon. What are the chief products resulting from the heating of soft coal without access of air? How does coal gas differ chemically from water gas? Under what conditions does a combustible substance burn with a flame?

Name two purposes for which graphite is commonly used.

8. Name three substances occurring in nature that are composed of calcium carbonate. What substances are formed when calcium carbonate is highly heated? What change takes place when water is added to the solid product thus formed? What use is made of the latter substance? What chemical change occurs when it is exposed to the air?

What is plaster of Paris? What is the chemical difference between the hardening of mortar and the setting of plaster of Paris?

D

Answer one question from this group.

9. A tube containing copper oxide (CuO) weighs, with its contents, 64 grams. This tube is then heated to redness, and hydrogen passed through it. When cooled, the tube with its contents is again weighed and the weight is now found to be 60 grams. What volume of hydrogen, measured under standard conditions, has united with the oxygen of the copper oxide? What weight of the copper oxide has been decomposed, assuming that it has been reduced to metallic copper? (Atomic weights: H = 1, O = 16, Cu = 64; weight of 1 liter of hydrogen under standard conditions = 0.09 grams).

10. What weight of crystallized sodium carbonate ($Na_2CO_3.10\ H_2O$) is required to neutralize completely 196 grams of sulphuric acid? (Atomic weights: Na = 23, O = 16, C = 12, H = 1, S = 32).

The volume of carbon dioxide evolved in the above reaction is approximately 4450 cc. under standard conditions. Calculate its volume at 890 mm. pressure and 27°C.

Harvard University.

The four starred questions must all be answered. Of the others, answer only three.

*1. (*a*) What happens when ammonia is passed over heated copper oxide? Write the equation.

(*b*) What are the characteristic properties of the products?

(*c*) What does this experiment show concerning the composition of ammonia?

*2. Complete the following equations, using formulæ:

Manganese dioxide + hydrochloric acid = ?

Hydrogen sulphide + copper nitrate = ?

Slaked lime + sulphuric acid = ?

*3. What is the least weight of pure sulphuric acid which would

be necessary to set free exactly ten grams of nitric acid from potassium nitrate?

H = 1 N = 14 O = 16 S = 32 K = 39

*4. State the Law of Multiple Proportions. Explain this law by means of examples.

5. Give one formula each of compounds of univalent, bivalent, trivalent, quadrivalent, quinquivalent, and sexivalent elements, and indicate in each case which element has the valence in question.

6. How may a salt soluble in water be freed from (*a*) insoluble impurities, (*b*) soluble impurites?

7. A gas has the formula C_2H_2. What is the weight of one litre of this gas under standard conditions?

One litre of oxygen at 0° C. and 760 mm. weighs 1.43 grams.

8. (*a*) What is the effect of dissolved substance upon the boiling and freezing points of water?
   (*b*) How does this effect vary with the quantities and natures of the dissolved substances?

9. (*a*) How may ammonia gas be made? Write the equation.
   (*b*) Give the properties of this substance.

10. Describe one commercial method for making sulphuric acid.

Princeton University.

Any dishonesty in the examinations, including the giving as well as the receiving of aid, will, if detected, permanently debar the candidate from entering the University.

1. What is the law governing the combination of gases by volume? Give some examples illustrating this law. What is the hypothesis advanced to explain it? Show how this hypothesis gives rise to a method of expressing the weights of molecules.

2. One volume of oxygen at 100° C. will go to form how many volumes of steam under the same conditions? How will the number of molecules of each compare? What inference can be drawn from the last answer as to the character of the oxygen molecule? How do we account for the increase in the density when oxygen is converted into ozone?

3. What is the property which distinguishes compounds from mixtures? What is an element? What conditions must be taken into account in measuring the volumes of gases? By what instruments are these conditions measured? Give the laws which express the effect of these conditions.

4. To what constituent do acids owe their characteristic properties? Does this substance impart these properties to all its compounds? What is the theory advanced to explain the facts embraced in your answer? How do we explain the fact that some acids are stronger than others? Name some other facts which the above-mentioned theory explains.

5. Define the terms: atom, valence, equivalent, and grammolecule. Of what do the following processes consist: distillation, sublimation, electrolysis, neutralization, reduction, fermentation, precipitation?

6. What is the basis of the Mendeléef classification? What evidence have we that this is a natural system? Discuss the properties of the elements in some natural family in such a way as to show their apparent relation.

7. Give the properties of the element oxygen; give two methods for its preparation (with reaction equations); discuss its importance in natural processes. Give the formulas for all the oxides of hydrogen, nitrogen, carbon, and silicon.

8. Describe the different forms of carbon and sulphur. Give the method of preparation of sulphuric, nitric, and hydrochloric acids, with the reaction equations.

9. Give the physical and chemical properties of the metals zinc and lead. How do arsenic and antimony differ from the true metals? What are alloys? Give the tests for iron, sodium, and silver.

10. What weight of chlorine can be prepared from 78g rock salt, containing 99 per cent NaCl? How much manganese dioxide and sulphuric acid would be required to carry out the reaction? What volume would the chlorine occupy under standard conditions? What volume of hydrochloric acid would it form?

Cl = 35.5, S = 32, O = 16,
H = 1, Na = 23, Mn = 55.

Sheffield Scientific School.

]The candidate may take the examination in Botany, Physics, or Chemistry].

N. B.—*No candidate will be accepted in this subject unless he has had a laboratory course. Every candidate must attach to his answer paper in chemistry a statement signed by his instructor of the work that he has done in this subject.*

1. Define atom. Give the laws of definite and multiple proportion.

2. Describe the ordinary method for making hydrochloric acid, and sketch the apparatus used.

3. Write the equations for the reactions (if any) when dilute sulphuric acid acts upon the following bodies: (1) aluminum hydroxide, (2) magnesium oxide, (3) zinc, (4) ferrous sulphide, (5) potassium carbonate.

4. Describe the visible changes when a solution of copper sulphate is mixed with solutions of each of the following: Hydrogen sulphide, cold sodium hydroxide, boiling sodium hydroxide, barium chloride. Write equations.

5. How many grams of zinc are required to make 50 litres of hydrogen by reacting with hydrochloric acid?

6. State whether each of the following changes is an oxidation or a reduction, with reasons: (1) chlorine to hydrochloric acid, (2) silver to silver bromide, (3) mercuric chloride to mercurous chloride, (4) phosphorus to phosphoric acid.

Atomic weights zn=65, cl=35.5, H=1.

One litre of hydrogen under normal conditions weighs 0.09 grams.

Case School of Applied Science.

1. Describe two experiments to explain the difference between a chemical and a physical change.

2. Define an atom, a molecule, atomic weight, molecular weight, an acid, a base, a salt, and give an example of each.

3. State the laws of definite and multiple proportions and give examples of each.

4. What weight of magnesium sulphate can be made from 1,000 grams of sulphuric acid? Give chemical reaction. Atomic weights, Mg, 24: S, 32: O, 16: H, 1.

5. Describe the preparation of the element chlorine with chemical reaction: describe the properties of chlorine, and its principal use.

6. Describe the differences between metallic zinc and phosphorus, physical and chemical, to illustrate a metallic and a non-metallic element. Write two chemical reactions to illustrate your definition.

7. What oxides are formed by the combustion of carbon, phosphorus, lead, and iron? Describe the properties of these oxides.

What is the composition of epsom salts, saleratus, green vitriol, blue vitriol, alum, niter?

RAMSAY'S DISCOVERY OF THE DEGRADATION OF COPPER TO LITHIUM.

Sir William Ramsay has recently made an announcement which, coming from so high a source, must be treated with respect and which, if borne out, must rank with his famous discovery of the transformation of radium emanation into helium. He states that after long experimenting with the effect of various combinations brought into contact with radium emanation, he has observed that copper compounds are transmuted or "degraded," in his own words, to lithium. After a solution of copper phosphate has been treated with the emanation and the copper then removed, the spectrum of the residue exhibits the red line of lithium. According to newspaper interviews, the experiment has been repeated so often with so many precautions, both with copper nitrate and copper sulphate, that there can be no doubt of the correctness of the observation. Other nitrates were experimented with and no lithium line was observed, nor was it possible to obtain the lithium line before the solution of copper phosphate was brought into contact with the emanation. According to Sir William, the only conclusion to be drawn from these observations is that the copper acted upon by the emanation has been degraded to the first member of the group of elements to which it belongs, namely, lithium. A full report will be made at the end of August, in the Transactions of the Chemical Society, and until that report is published, it is inadvisable, and indeed impossible, to discuss with any degree of thoroughness a discovery which, if substantiated, must certainly be regarded as one of the most brilliant chemical revelations of this radio-active age.—*Scientific American.*

A LIST IN PHYSICS.

At the meeting of the Physics Conference of the Michigan Schoolmasters' Club at Ann Arbor, Mich., March 28-30, 1907, the accompanying list of experiments for Laboratory work in Physics, for Secondary Schools was unanimously adopted. It was further recommended that each school select such exercises as it can best equip for, the number chosen not to be less than forty, of which at least twenty-five shall be quantitative. The committee that compiled the list was appointed at the March meeting, one year ago, and consisted of H. N. Chute of the Ann Arbor High School, Chairman, C. F. Adams of the Detroit Central High School, and Prof. C. W. Greene of Albion College.

I. Simple Measurements.

1. Linear:—(*a*) Meter-rod; (*b*) Diagonal scale; (*c*) Vernier Caliper; (*d*) Micrometer caliper.
2. Volume:—The Graduate and burette.
3. Mass:—The balance, Beam or Jolly.—Six problems.

The purpose of the above list is to give the student an opportunity to become familiar with the accurate use of these instruments. The method of doing so and the most suitable time for taking them up are left to the judgment of the teacher.

II. Properties of Matter.

1. Elasticity:—(*a*) Stretching; (*b*) Bending.
2. Osmosis.— Three problems.

III. Mechanics of Solids.

1. Composition of Forces:—(*a*) Concurring; (*b*) Parallel.
2. Accelerated Motion.—The Inclined Plane Method or Atwood's Machine.
3. The Pendulum.—The law of Length and determination of g.
4. Curvilinear Motion.—Testing and illustrating the laws.
5. The Lever.—The principle of moments.
6. The Inclined Plane.—
7. The Pulley.— Eight problems.

IV. Mechanics of Fluids.

1. Surface Tension:—(*a*) General phenomena; (*b*) Capillary action; (*c*) Drop size.
2. Pressure in liquids.—
3. Buoyancy:—(*a*) Solids that sink in water; (*b*) Solids that float.
4. Density:—(*a*) Solids that sink in water; (*b*) Solids that float in water; (*c*) Liquids.
5. Air pressure.—
6. Measuring heights with barometer.
7. Boyle's law. Twelve problems.

V. Sound.

1. Velocity of sound:—(*a*) In air by resonance; (*b*) In solids by Kundt's method.
2. Scale ratios (diatonic).

3. Frequency:—By chronograph, siren, or sonometer.
4. Laws of strings.—
5. Law of beats.—
6. Law of air columns.— Seven problems.

VI. LIGHT.

1. Images by small apertures.
2. Photometry.—
3. Reflection:—(*a*) The law; (*b*) Measuring the angle of a prism.
4. Focal length:—(*a*) Concave mirror; (*b*) Convex lens.
5. Images:—(*a*) Plane mirror; (*b*) Spherical mirror; (*c*) Lenses.
6. Refraction:—(*a*) Index of water; (*b*) Index of glass.
7. Magnifying power.
8. Spectra.—
9. Mixing colors.—
10. Diffraction.—Wave length of light. Fifteen problems.

VII. HEAT.

1. Thermometry.—Testing fixed points on thermometer and making table of corrections.
2. Expansion:—(*a*) Linear; (*b*) Cubical of liquids; (*c*) Air under constant pressure.
3. Specific heat:—(*a*) Solids; (*b*) Liquids.
4. Melting points of solids.
5. Heat of fusion of ice.
6. Boiling points of liquids.—Effect of pressure.
7. Heat of vaporization of water.—
8. Heat lost in solution.
9. The Dew Point.— Twelve problems.

VIII. MAGNETISM.

1. The Bar Magnet:—(*a*) Law of magnetic action; (*b*) Locating the poles; (*c*) Lifting power.
2. Diamagnetism.—
3. Surface distribution of magnetism in a slender magnet.
4. Magnetic fields.— Six problems.

IX. ELECTRICITY.

1. The Electroscope.
2. The Voltair Cell.
3. Magnetic qualities of the electric current.—The galvanometer.
4. Constructing an E. M. F. series.
5. Mutual action of currents.
6. Measurement of Electrical Resistance of a wire.—Effect of length, diameter, material, and temperature.
7. Measurement of Battery Resistance.—Single, parallel, series.
8. Measurement of E. M. F. of a battery.—Single, parallel, series.
9. Fall of potential along a conductor.
10. Reduction factor of a galvanometer.—The ammeter.
11. Current induction.—
12. The Dynamo.—Studying the effect of speed, iron core, amount of wire, etc., on E. M. F. Twelve problems.

Reference Books in Physics.

(Suggested by H. N. Chute.)

A Ten Dollar List.

Lodge's Mechanics	$1.50	
Zahm's Sound and Music	3.50	
Edser's Light	1.50	
Madan's Heat	3.00	
Thompson's Electricity and Magnetism	1.40	$ 10.90

A Fifteen Dollar List.

Add to the ten dollar list the following:—

Tait's Properties of Matter	$2.25	
Lodge's Pioneers of Science	2.50	$ 15.65

A Twenty-five Dollar List.

Add to the fifteen dollar list the following:—

Boys' Soap Bubbles	$1.25	
Hopkin's Experimental Science	5.00	
Gray's Physical Tables	2.00	
Carhart's Primary Batteries	1.50	$ 25.40

A Fifty Dollar List.

Add to the twenty-five dollar list the following:—

Maxwell's Matter and Motion	$0.50	
Thompson's Light, Visible, and Invisible	1.50	
Bottone's Electrical Instrument Making	0.50	
Lodge's Modern Views of Electricity	2.50	
Tait's Recent Advances in Physical Science	2.50	
Threlfall's Laboratory Arts	1.50	
Cajorie's History of Physics	1.50	
Atkinson's Electrical and Magnetic Calculation	1.50	
Duncan's New Knowledge	2.00	
Henry and Hora's Modern Electricity	1.00	
Underhill's Electromagnet	1.00	
Maxwell's Theory of Wireless Telegraphy	2.00	
Edser's Heat	1.40	
Glazebrook's Mechanics and Hydrostatics	2.25	
Wright's Light	2.00	
Perry's Steam, Gas, and Oil Engines	2.50	$ 51.55

A Hundred Dollar List.

Add to the fifty dollar list the following:—

Atkinson's Ganot	$5.00	
Watson's Physics	3.50	
Fleming's Magnets and Electric Currents	3.00	
Preston's Theory of Light	5.00	
Preston's Theory of Heat	5.50	
Lodge's Lightning Conductors and Lightning Guards	4.00	
Carhart's University Physics	3.00	
Blaserna's Theory of Sound	1.50	
Lommel's Nature of Light	2.00	
Perry's Practical Mechanics	2.50	
Cooper's Primary Batteries	3.00	
Tyndall's Heat as a Mode of Motion	2.00	
Tyndall's Sound	2.00	
Jones' Physical Chemistry	4.00	
Stewart's Conservation of Energy	1.50	
Homan's A B C of the Telephone	1.00	
Bottone's Electric Bells	0.50	
Hare's Construction of Large Induction Coils	1.80	
Treadwell's Storage Battery	1.75	
Maycock's Electrical Wiring	1.75	$105.85

A List of Forty Laboratory Exercises for which Good Apparatus Can be Bought for $100.

1. The metre rod. 2. The diagonal scale. 3. The vernier caliper. 4. The micrometer caliper. 5. Volume. 6. Mass. 7. Composition of concurring forces. 8. Composition of parallel forces. 9. The pendulum. 10. Accelerated motion. 11. Buoyant force on a body that sinks. 12. Buoyant force on a body that floats. 13. Density of a solid that sinks in water. 14. Density of a solid that floats in water. 15. Density of a liquid. 16. Boyle's law. 17. Velocity of sound in air. 18. Frequency of a fork. 19. Law of strings. 20. Photometry. 21. Law of reflection of light. 22. Angle of a prism. 23. Focal length of a concave mirror. 24. Focal length of a convex lens. 25. Images by plane mirrors. 26. Images by curved mirrors. 27. Images by lenses. 28. Index of refraction of glass. 29. Testing a thermometer. 30. Linear coefficient of expansion. 31. Cubical coefficient of expansion of a liquid. 32. Specific heat of a metal. 33. Heat of fusion of ice. 34. The bar magnet. 35. Magnetic fields. 36. The voltaic cell. 37. Oersted's experiment. 38. E. M. F. series. 39. Electrical resistance of a conductor. 40. The E. M. F. of a battery.

LIST OF NEEDED APPARATUS WITH PRICES.

The metre rod	$ 0.30	Boyle's law app	0.75
Diagonal scale	0.15	Beaker, 1 l. copper	1.00
Dividers	0.25	Beaker, ¼ l. nickel plated	0.75
Vernier Caliper	2.00	Iron ball, 1 in. diam.	0.10
Micrometer Caliper	4.00	Expansion app.	2.00
Magnifier	0.25	Thermometer	0.75
Graduate, 250 cm.³	0.50	Bottle, wide mouth, 1 qt.	0.10
Pendulum, mercury contact, mounted on wall bracket	1.80	Funnel, 4 in.	0.20
Duff's inclined plane	3.90	Copper steam generator	1.00
Three draw scales, 0—2000 gm., provided with cradles.	1.20	Bunsen burner	0.25
Three cabinet clamps	0.60	Iron stand, 2 rings	0.35
Glass beaker	0.10	Concave lens, 3 in. diam.	0.75
Density bottle	0.25	Convex lens, 3 in. diam.	0.75
Wooden bar, loaded	0.30	Convex mirror, 3 in. diameter	0.75
Solid brass cylinder	0.25	Concave mirror, 3 in. diameter	0.75
Weights, 1 mgm—50 gm.	2.50	5,000 ohm coil	1.50
Jolly balance	4.50	Two Leclanche cells	1.20
Iron weight, 500 gm.	0.35	Resistance box	5.00
Graduated bar	0.20	Spool of wire for measurement	0.40
Two universal supports	2.20	D'Arsonval galvanometer	6.50
Protractor	0.15	Wheatstone bridge	4.00
Prism, flint glass	0.65	Contact key	1.00
Plane mirror, 3 in. by 3 in.	0.20	Pocket compass	1.00
Two lamps	0.40	posts	0.75
Photometer with accessories	10.00	Compass block with binding	
Three forks giving major chord with C	3.75	Daniell cell	1.00
Sonometer	6.00	Voltaic cell with six plates	1.00
Glass tube, 2.5 cm. by 50 cm.	1.00	Horseshoe magnet	0.15
C-fork	1.00	Two bar magnets	0.30
Mercury, 2 lbs.	1.70	Balance, 1 kgm. with weights, duty free	15.50
		Total	$100.00

A SELF-IGNITING ALLOY.

A pysophoric or self-igniting alloy composed of 30 per cent iron and 70 per cent cerium is the discovery of S. Auer Von Welsbach, the inventor of the Welsbach lamp. When the alloy is scratched so that fine particles are produced, these burn spontaneously. The alloy is made by adding finely divided iron to molten cerium, and will be used in the manufacture of self-lighting gas burners.

ARTICLES IN CURRENT MAGAZINES.

Garden Magazine for September: "What to Do With the Apple Crop," F. H. Valentine; "Saving the Garden Plants from Frost," Parker Thayer Barnes; "California Bulbs in an Eastern Garden," Flora Marble; "Fall Plowing and Draining," V. E. Warren; "The Twelve Best Shade Trees," Leonard Barron; "Four Plans for a 75x100 Ft. Plot," F. C. Leible; "Autumn-Blooming Crocuses and Their Allies," Wilhelm Miller. For October: "Why You Should Grow Dwarf Fruit Trees," P. T. Barnes; "Mushrooms in Frost-Proof Buildings," William McCollom; "A Notable Improvement in Narcissus," Thomas McAdam; "Making a Frost-Proof Storage Cellar," A. T. Raven; "Trees and Shrubs for Fall Planting," Leonard Barron; "Flowers that Bloom Amid the Snow," Wilhelm Miller; "The Easiest Way to Have Flowers all Winter," Henry Maxwell.

Ores and Metals for August 20: "Methods of Cleaning Up a Cyanide Plant," by Al. N. Martin; "The Black Sands of the Snake River," Geo. W. McGhee. For September 5: "Tungsten and Its Use as a Hardener of Steel," by J. Fount Lewis; "The Manufacture of Slag Cements," by Edwin E. Eckel.

Photo-Era for September: "Illustrative Photography," C. H. Claudy; "Exposure in Enlargement," F. H. Jeffree; "How to Make and Use a Duplicator," John Boyd; "A Rapid-Action Printing Frame, and Its Possibilities," O. H. Todd and O. Von Engeln; "Photography and the X-Rays," Malcolm D. Miller, M. D., and F. J. Garbell.

Physical Review for September: "Heat of Evaporation of Water," Arthur W. Smith; "Specific Heat of Solutions, V," William F. Magie; "Inductance of Straight Conductor," K. Ogura and C. P. Steinmetz; "A Study of the Propagation and Interception of Energy in Wireless Telegraphy, Part I," Charles A. Culver.

Popular Science Monthly for August: "The Problem of Age, Growth, and Death," Professor Charles S. Minot; "The Place of Linnæus in the Unfolding of Science: His Views on the Class Mammalia," William K. Gregory; "Recent Legislation on the Mississippi River," Robert Marshall Brown; "Notes on the Development of Telephone Service," Fred DeLand; "The Balsam Peaks—the Heart of the South Appalachian Mountains," Spencer Trotter; "The Reawakening of the Physical Conscience," Dr. Richard Cole Newton; "Some Little-Known Mexican Volcanoes," Professor Herdman F. Cleland. For September: "The Problem of Age, Growth, and Death," Professor Charles S. Minot; "A Scientific Comedy of Errors," Professors T. D. A. Cockerell and F. B. R. Hellems; "Notes on the Development of Telephone Service," Fred DeLand; "The Health of American Girls," Nellie Comins Whitaker; "Some Ethical Aspects of Mental Economy," Professor Frederick E. Bolton; "The Chinaman and the Foreign Devils," Charles Bradford Hudson; "Poe as an Evolutionist," Frederic Drew Bond; "Mars as Seen in the Lowell Refractor," G. R. Agassiz.

Review of Reviews for September: "Saint Gaudens and American Sculpture," by Ernest Knaufft, with portrait and other illustrations; "Has Arkansas a Diamond 'Field'" by Robert S. Lanier; "The West Indies in Commerce," by Lewis R. Freeman, with illustrations; "Developing a National Type of Horse," by Arthur Chapman, with portraits and other illustrations; "The Prohibition Wave in the South," by John Corrigan, with portraits; "How Long Will Our Coal Supply Last?" by John Llewellyn Cochrane, with chart and diagram; "Are Secret Societies a Danger to Our High Schools?" by Marion Melius; "Why is Interest High?" by George Iles.

Scientific American for August 10: "The 25-Knot Turbine Liner 'Lusitania,'" "The Erection of the Blackwell's Island Bridge," "A Revolution in Postal Car Construction," "The Greatest of Mastodons." August 31: "Some Notable German Bridges," "The Sheep Killing Kea."

Scientific American Supplement for August 3: "The Form and Energy of Sea Waves." August 24: "History of Map-Making," Col. C. W. Larned; "A Mammoth Cave Cathedral," H. C. Hovey. For August 31: "History of Map-Making."

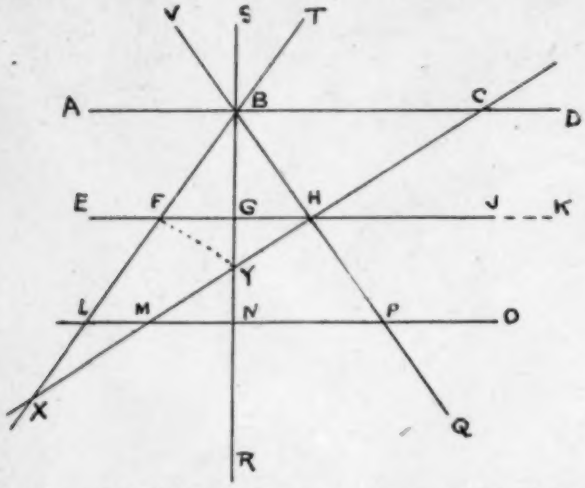
Forestry and Irrigation for August: The entire number should be read by those interested in forestry. Special articles—"Our National Parks," Mrs. T. J. Mott; "Hardy Catalpa for Profit," Prof. Frank G. Miller.

A SUGGESTION FOR REVIEW IN GEOMETRY.

By C. A. Petterson,

Jefferson High School, Chicago.

Here is a composite figure drawn almost at random. It may be of interest to some. Such figures can be drawn on a hectograph and copies given to each pupil for review work. Pupils are always interested in the possibilities of the figure. A great deal of time usually taken in drawing is saved, and review work is presented in a somewhat novel form. After a few such figures, it is easier to make use of the plan of having pupils draw diagrams at their seats, the others following as the pupil at the board describes his drawing.



ANOTHER NOTE ON COOLING BY EXPANSION.

Professor W. S. Franklin of Lehigh University sends us the following method. He says: "I have for many years used the following very simple experiment for showing the cooling of a gas by expansion. An ordinary flask containing a little water is heated to, say, 50°C. and shaken vigorously so as to saturate the contained air with water vapor. The mouth is then applied to the flask and a vigorous suck produces a fog that can be easily seen by an entire class if the flask is held in front of a window. Allow air from the lungs to flow back into the flask, and the fog suddenly disappears. The effect may be obtained many times in succession by repeatedly sucking air out of the flask and then allowing it to flow back again from the lungs.

REPORT OF THE NEW YORK ASSOCIATION OF BIOLOGY TEACHERS.

At the April meeting of the N. Y. Association of Biology Teachers the chief feature of the program was a debate on the question: Resolved that it is to the best interests of education that Biology be required of all first year pupils in the High School.

Mr. Bedford of the Brooklyn Commercial High School opened the debate for the affirmative. He claimed for science in general a prominent place in the curriculum of Secondary Schools for three reasons: (1) its value in inculcating proper habits of thought, (2) its value from the standpoint of culture, (3) its practical utility. In considering the claims of Biology to be the science best adapted for the first year, the character of the course to be taught is the thing to be considered. A course covering abstract biological principles, a comprehensive study of morphology, histology, and embryology should not be attempted earlier than the fourth year. A course intended to train in right habits of thought and to teach a few of the more important biological principles which have influenced modern life, may come in the first year. It should also give the child a keen interest in living things and some insight into their economic importance. It should lead him also to realize also the importance of personal hygiene. The addition of a few fundamental facts in Physics and Chemistry, which are necessary to comprehend the Biology, does not require much time. The result of such a combination is a first year course in science which appeals to pupils of that age as no other one science can.

Dr. Linville, of the DeWitt Clinton High School, opened for the negative. He claimed that the reason for its place in the first year was the legal requirement of teaching Physiology then, which is not conclusive evidence that either belongs there. Many pupils leave the high school at the end of the first year, and the desire to give as great a number as possible some biological training is urged as another reason. This reason might apply equally well to other sciences, such as economics.

When for these reasons it is taught in the first year, it cannot be taught as a science, but is an informational subject. This is not the proper way to teach it. "Biology should be taught for its principles, (1) because of the basis given to human physiology, a subject most useful on account of the relation a scientific understanding of the subject among educated people has to the solution of problems of public health; (2) because if education is 'adaptation to environment' it is necessary for men to comprehend their relation to the range of organic life, to understand the evolutionary processes which made man's existence possible, and to grasp the situation as it exists today as portrayed in the economic relation of man to all organic things. Biology should be taught scientifically; (3) because of the useful application of the doctrine of organic evolution to knowledge in general, and (4) because the easy approach to the comprehension of the mental life of man is through the study of the behavior of animals."

If the proper position of the sciences is to be learned, their logical relation must be considered. Chemistry and Physics do not presuppose a course in Biology, but some knowledge of these subjects is necessary for even informational first year Biology. The logical order is therefore Chemistry, Physics, Biology, since it is a waste of time to prime pupils on diluted Chemistry and Physics for a precarious understanding of Biology.

In the general discussion which followed the opening speeches, it was contended that "expediency" was a proper reason for placing Biology in the first year, since the teacher must teach the children who have not been brought up in ideal conditions and do the best thing for them rather than teach an ideal course. The average High School boy knows nothing of nature and will never learn to love it unless his interest is kindled before the last year of his course. He will not be able to comprehend biological principles then if he has no previous familiarity with common growing things. Since at present nature study in the city graded schools is for various reasons most inadequate, it must not be depended upon to furnish much biological information. In closing it was generally conceded that it is impossible to settle upon the best time, without at first agreeing upon the character of the course and that the character of the course depends largely on the previous training and environment of the pupils.

MARTHA F. GODDARD, *Secretary.*

MEETING OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The seventh annual meeting of the Central Association of Science and Mathematics Teachers will be held at the McKinley High School, St. Louis, on Friday and Saturday, November 29 and 30, 1907. The speakers on the general program are Professor Florian Cajori, Colorado College, Professor S. W. Stratton of the Bureau of Standards, Washington, and Superintendent Soldam of St. Louis. Among the speakers on the sections programs are: George B. Halsted, Greeley, Colo., E. R. Hedrick, Columbia, Mo., G. C. Shutts, Whitewater, Wis., W. H. Henderson, Ann Arbor, Mich., Lindley Pyle, St. Louis, F. H. Ayers, Kansas City, Mo., W. A. Noyes, Urbana, Ill., Lynds Jones, Oberlin, Ohio, William Trelease, St. Louis, H. W. Norris, Grinnell, Iowa, N. A. Harvey, Ypsilanti, Mich., W. W. Harte, Indianapolis, Ind., J. A. Drushel, Teachers' College, St. Louis, and Ormond R. Miller, The Blow School, St. Louis.

On Friday evening a supper will be given for the members of the Association at a charge of fifty cents a plate. Several excursions to points of interest have been arranged for Saturday afternoon, among which that to the Missouri Botanical Garden will be of general interest. The meeting promises to be a large and enthusiastic one. The local St. Louis committee are sparing no effort to make the 1907 meeting the banner session. The program is rich in interest and should call out a large attendance. More detailed announcement will be made in the next issue of this magazine and in the programs which will soon be ready for distribution.

The Mathematics Section at the Meeting of the Central Association.

The programme for the meetings of the Mathematical Section of the Central Association of Science and Mathematics Teachers at St. Louis in November has been arranged so as to throw into the focus the committee reports on algebra and geometry. The report of the Geometry Committee was printed during the year and has been widely distributed. Copies may still be had by sending a two-cent stamp to the Secretary, Miss Mabel Sykes, 438 E. 57th St., Chicago. The algebra report in preliminary form is printed in the current number of SCHOOL SCIENCE AND MATHEMATICS. Copies of both these reports will be on hand for distribution to all those who attend the meetings in St. Louis. One entire session will be devoted to the discussion of the Geometry report, which will be led by Professor George B. Halsted of Greeley, Colorado, Professor George C. Shutts of Whitewater, Wisconsin, and Mr. C. W. Newhall of Faribault, Minn. The other session will be devoted to the presentation of the algebra report by the chairman of the committee, and its discussion, led by Professor Florian Cajori of Colorado Springs, Professor E. R. Hedrick of Columbia, Mo., and Mr. W. W. Hart of Indianapolis, Ind.

The Mathematics Section is endeavoring through these reports to do constructive work in the way of improving the pedagogy of secondary mathematics. Wide opportunity will be given for discussion, and it is hoped that every teacher of secondary mathematics in the Middle West will endeavor to be present and assist in this good work.

PERSONAL ITEMS.

W. H. Stuart of the Manual Training High School, Indianapolis, Ind., has accepted the principalship of the Cleveland High School, St. Paul, Minn.

Mr. George A. Harper is doing strong work in Mathematics at the New Trier Township High School, Willmette, Ill. This school is growing rapidly.

Mr. Hitchcock has been professor in Fargo College, Fargo, N. D., for some years, and has recently spent a year in the University of Cincinnati.

Miss Augusta Engels, who has for two years taught Science and Mathematics at West Chicago High School, has been appointed instructor in Mathematics at Wallace, Idaho.

George F. Weida (Ph.D. Johns Hopkins University) has been elected to the "Bowler professorship" at Kenyon College; with Mr. F. L. Hitchcock (A.B. Harvard) as assistant professor.

Mr. C. J. Smith, who for some years has had charge of the Mathematics at the Evansville (Ind.) High School, has been called to the State Normal School at Indiana, Pa., as Instructor in Mathematics.

Miss Meta Mannhardt has charge of the mathematics in Brownell Hall, a private school for girls in Omaha, Nebr. Miss Mannhardt has

made special preparation for her work in this line at the University of Chicago.

Mr. F. D. Posey and Miss Hazel Anderson, A.M. (Chicago), have become instructors in Mathematics at Indianapolis, the former in the Shortridge High School, and the latter in the Manual Training High School.

N. J. Lennes, joint author of Slaught and Lennes' Algebra goes to the Mass. Institute of Technology as Instructor of Mathematics. For a number of years Mr. Lennes has been teaching Mathematics in the Wendell Phillips High School, Chicago.

Mr. Frank H. Stevens is the efficient head of the department of mathematics in the high school of Terre Haute, Ind. The department numbers some six or seven teachers, several of whom studied last summer at the University of Chicago.

Another westerner and one well known to our readers of the past is F. L. Holtz, State Normal School, Mankato, Minn. He now has charge of the Science and Nature Study department in the Training School for Teachers, Brooklyn, N. Y.

Dr. Weida has been professor of Chemistry in the Kansas State Agricultural College at Manhattan for six years; and at Ripon College (Ripon, Wis.) for three years; and has also taught for a short time in the city of St. Louis (Central High School).

A well-deserved promotion is that of Dr. John C. Hessler, from an instructorship in the University of Chicago to Professor of Chemistry in the James Millikin University, Decatur, Ill. Dr. Hessler was formerly Instructor of Chemistry in the Hyde Park High School, Chicago. He is joint author of "Hessler and Smith's Chemistry."

Dr. E. N. Transeau, recently of the Carnegie Experiment Station, Cold Spring Harbor, Long Island, is in charge of the work in botany in the Eastern Illinois State Normal School, Charleston, Ill., succeeding Dr. O. W. Caldwell, who has been appointed associate professor of botany in the University of Chicago and supervisor of nature study in the School of Education.

Professor J. C. Shedd, for the past seven years professor of physics at Colorado College, Colorado Springs, has been elected dean of the College of Letters and Science of Westminster University, Denver, Colo. Dr. Shedd will also hold the chair of physics. He is succeeded by Charles W. D. Parsons, Cornell, 1897, Secretary-Treasurer Central Association of Science and Mathematics Teachers.

Mr. W. W. Gorsline, Ph.B. (Chicago), who for two years has taught the higher mathematics at the Goshen (Ind.) High School, has been appointed instructor in Mathematics at Burlington, Iowa. Miss Nancie MacArthur has taken Mr. Gorsline's place at Goshen. This is one of the schools where the six-year high school plan is in full operation and apparently with marked success. Two years of college work in Latin, English, and Mathematics are now done under the close supervision of the University of Chicago. In this way many boys and girls are enabled to start, and ultimately to finish, a college course, who otherwise would go no further than the high school.

BOOKS RECEIVED.

Report of the Committee on the Promotion of Teachers. New York City.

The Study of Science by Young People, by William S. Franklin.

Exercises in Elementary Agriculture, Plant Production, by Dick J. Crosby.

Reports of the Groszmann School for Atypical Children.

Proceedings of the Department of Superintendence of the National Educational Association. February, 1907.

Education by Plays and Games, by George E. Johnson, Superintendent of Playgrounds, etc., Pittsburg. Ginn & Co.

Elements of Physiology, by Theodore Hough, Professor of Biology in Simmons College, and William T. Sedgwick, Professor of Biology in the Massachusetts Institute of Technology. viii + 321 pages. Ginn & Co.

The Elements of Mechanics for Colleges and Technical Schools, by W. S. Franklin and Barry McNutt, Professors of Physics in Lehigh University. ix + 283 pages. Macmillan Co.

Evolution and Animal Life, by David Starr Jordan, President of Leland Stanford University, and Vernon L. Kellogg, Professor Entomology in Leland Stanford University. xi + 489 pages. D. Appleton & Co.

Catalog of the Chemical Collection in the Phillips Exeter Academy Chemical Laboratory, compiled by Wilhelm Segerblom, Instructor in Chemistry. Pp. 74. Exeter, N. H., 1907.

Study Questions in Qualitative Analysis, by Wilhelm Segerblom, Instructor in Chemistry, Phillips Exeter Academy. 1906. Pp. 22.

The Elements of Mechanics, a text-book for Colleges and Technical Schools, by W. S. Franklin and Barry McNutt. Pp. ix + 283. New York: The Macmillan Co., 1907.

Laboratory Exercises in General Zoölogy, by Glenn W. Herrick. 1907. Pp. 106. American Book Company. Price, 60 cents.

A Text-book of Organic Chemistry, by Professor A. F. Holleman, University of Amsterdam. Translated from the third Dutch edition by A. Jamieson Wacker, assisted by Owen E. Mott. Second English edition. 8vo, xviii + 589 pp. Cloth, $2.50. John Wiley & Sons, New York, 1907.

Webster's New Standard Dictionary, high school and collegiate edition, 900 illustrations, 24 full page plates, 832 pages, revised edition, 1907. Laird & Lee, Chicago. Price, $1.00.

BOOK REVIEWS.

The Making of a Teacher, a contribution to sane phases of the problem of religious education, by Martin G. Brumbaugh, Professor of Pedagogy in the University of Pennsylvania. Pp. 351. 4th edition, 1905. Philadelphia: The Sunday School Times Co. $1.00 net.

Although primarily intended for Sunday School teachers, it is of

value to any teacher who earnestly desires to accomplish the best results. The purpose has been to vitalize certain educational principles, to push their application home to the conscience, and, if possible, to inspire in the heart of the teacher a great desire to make the most of the opportunities that are his.

Laboratory Exercises in Elementary Physics, by Hugo Newman, Principal of Public School 33, The Bronx, New York City. In four books, $1.50 per dozen. Ginn & Co., Publishers.

These exercises consist of four books as follows: Book I, Measurement, Gravity, Mechanical Powers; Book II, Mechanics of Liquids and Gases; Book III, Sound and Heat; Book IV, Light, Magnetism, and Electricity.

The teacher who advocates the introduction of elementary physics into the seventh and eighth grades will find in these admirable exercises what has long been needed. They present to the pupils an elementary laboratory course, the experiments consisting of those standards which illustrate the more common laws of physics. No expensive apparatus is needed. The work could very well be carried out with the apparatus described on page 702 of this issue. The instructions are made very plain, too plain if anything. A picture of the apparatus used in each experiment is shown with it. The exercises constitute a note book, as well as book of instruction, the pupil being guided in each experiment as to how his notes should appear. C. H. S.

Merrill's English Texts.—The Rime of the Ancient Mariner and Other Poems, by Samuel Taylor Coleridge. 1907. C. E. Merrill & Co., 114-60 East Second Street, New York. Price, 25 cents.

This is the first of a series of volumes which will include, in complete editions, those masterpieces of English literature that are best adapted for the use of schools and colleges. It has been prepared with the purpose of giving to students a full and profitable acquaintance with the poet's work and place in literature. For that reason other selections besides "The Ancient Mariner" have been included in the volume in order that Coleridge may not remain forever to the student a poet of one poem alone. In connection with the text a critical and historical introduction is given, including a sketch of the life of the author and his relation to the thought of his time. Ample explanatory notes of such passages in the text as call for special attention are supplied, but irrelevant annotation and explanations of the obvious are rigidly excluded. In short, all necessary material is furnished for a complete working equipment for student and teacher. Other features of the edition are the bibliographical list for outside reading and a full-page portrait of the author.

A Laboratory Outline of General Chemistry, by Alexander Smith, University of Chicago, and William J. Hale, University of Michigan. Interleaved 3d edition, 1907. Pp. 136. The Century Co., New York. Price, 90 cents.

The book is intended for beginning classes in colleges. It is also well adapted for use in normal schools. 203 experiments are given.

The authors state that no one class is expected to perform all these. From one half to three quarters of the whole material they say can be covered in thirty-three weeks by a student working four to six hours a week. The outline is so arranged that an instructor can make such a selection as will suit the work he desires to give. A laboratory course of almost any character can be given.

A number of the experiments are valuable for lecture or demonstration purposes by teachers in secondary schools. Others are suitable for the bright pupil who gets ahead of his class and wants to do extra work.

A pamphlet giving selections of experiments for various kinds of work and lists of apparatus accompanies the Outline.

Every teacher of chemistry should have a copy on his desk.

C. M. T.

First Course in Algebra, by Albert Harry Wheeler, Teacher in Mathematics in the English High School at Worcester, Mass. Pp. xix + 664. $1.15. Little, Brown & Co., Boston, 1907.

In this book there are 28 chapters covering 664 pages, and including 8,000 examples and 3,000 mental exercises. It is intended to cover the ground of secondary algebra only. Principles and explanations are stated with great simplicity and directness. Reasons for all steps are insisted upon and drill in arthmetic is constantly kept up. A feature of the book that is both unique and distinctly commendable is the extensive use of mental exercise with easy problems. A few minutes, say 5 to 10 minutes daily, in such exercises will give pupils frequent opportunities to recite, give them confidence, and a certain amount of skill and precision in "rough and ready" thinking, and will strengthen them for the thought work of written problems.

Applied problems have to do with matters of modern interest to an unusual extent. Applications of algebra to familiar laws of physics are emphasized. Traditional absurdities are excluded, and graphs are early, extensively and persistently used. Certain more difficult paragraphs, important to fuller developments of topics, are given in such way as to make them easily omitted in a first reading, or altogether if necessary. The principle of checking results is taken seriously by the author, as having an educational value, as well as that of merely guaranteeing correct results. It is followed out in a way to beget independence of thought and confidence on the pupil's part. In a word, the book has embodied all of the modern pedagogical virtues of mathematical teaching, and that too, without any loss of what is really meritorious in the old modes. The only criticisms the writer cares to note are the too great bulkiness of the text to make it practicable for classes, and the too great tendency to develop algebra through its formal side from the outset.

The typography of the book is good, the binding is fair and the cuts on the graphs are well done. So much excellent matter, so well put up, and for so low a price strikes a Westerner as a little remarkable.

M.

Differential and Integral Calculus, by George A. Osborne, S. B. Walker Professor of Mathematics in the Massachusetts Institute of Technology. Revised edition, 1906. Pp. xii + 388. D. C. Heath & Co.

The original work of 1891, of which this is a revision, is well and favorably known to the professional public. In the present edition many changes have been made, and all for the betterment of what was already a good book. Demonstrations have been revised, new examples substituted, some rearrangements have been made and new illustrations and applications of differentiation are given. The chapter on series is new. In short the book has undergone thorough renovation.

Chapter X is an altogether admirable chapter on Maxima and Minima. The use of graphical pictures to visualize the theory embodied in the formulas and equations can hardly fail to "make the point" with the student. The essence of the matter is not masked in a maze of verbiage as is sometimes the case even with good books on calculus. Brevity, clearness and force are the characteristics of this chapter as to method of presentation.

The chapter on Simple Applications of Integration is another charming bit of text-book work. The Application of Integration to Plane Curves and to certain solids is also fine. The book is on the whole one of the most comfortably workable texts yet written for technological students of calculus. As it presents the subject, it will go far toward enabling engineering students to feel the great practical value of calculus.

The pages are remarkably free from typographical blemishes, and in its new flexible coat of "true blue" it is a pleasure to behold Teachers will be thankful for the rather full index of three close pages, and for the half-pocket form in which the publishers are furnishing it.

M.

An Elementary Treatise on Differential Equations, by Abraham Cohen, Ph.D., Associate in Mathematics, Johns Hopkins University. Pp. ix + 271. D. C. Heath & Co., 1906. Half leather, limp back, $2.00.

According to its author, "the primary object of the book is to teach the student how to integrate any equation, or system of equations, he is liable to come across." Theory is not ignored, for enough of it is given at least to impress the student that there *is* a theory of differential equations.

The chapter headings are: I. Differential Equations and Their Solutions; II. Differential Equations of the First Order and Degree; III. Applications; IV. Differential Equations of the First Order and Higher Degree than the First; V. Singular Solutions; VI. Total Differential Equations; VII. Linear Differential Equations with Constant Coefficients; VIII. Linear Differential Equations of the Second Order; IX. Miscellaneous Methods for Solving Equations of Higher Order than the First; X. Systems of Simultaneous Equations; XI. Integration in Series; XII. Partial Differential Equations; XIII. Partial Differential Equations of the First Order; XIV. Partial Differential Equations of Higher Order than the First; A General Summary, Answers and a Useful Index and References to Sources Consulted complete the scope of the book.

The treatments of the individual topics are clear and explicit, sufficiently illustrated and exemplified to make the text fairly easy reading for the student. The practice of citing the authorities used is recommended to American authors of college texts on mathematics as worthy of imitation. Aside from the question of fair play, it puts students on track of profitable lines of collateral reading, and exhibits something of the historical and human sides of the science.

The suggestive and informing notes at the foot of pages is an excellent idea. They supplement the thought of the text without interrupting it, and insinuate an added interest into the subject matter. The book is one of the most practicable texts yet published on the subject. The typography and makeup of the book are of high excellence, and the pocket-edition form adds to its convenience. M.

College Algebra, by Charles H. Ashton, Assistant Professor of Mathematics in the University of Kansas, and Walter R. Marsh, Head Master Pingry School, Elizabeth, N. J. Pp. ix + 279. Charles Scribner's Sons, 1907.

A blanket review of the formal side of all elementary Algebra, an unusually intensive and extensive treatment of radicals, theory of exponents, and quadratics, the elimination of series, continued fractions, and differentiation from the course in College Algebra, a very extended use of graphical representation, a clear and delightfully simple treatment of determinants, and an unusually full treatment of theory of equations, are the distinguishing features of this text.

After a particularly thoroughgoing treatment of simultaneous linear equations, of quadratics, of the character of the roots of the quadratic, comes a delightful chapter on graphs. Why this graphical clearing up of the matter of the roots of the quadratic and of the meaning of the solutions of quadratics should be delayed until all the old-time confusion has been first produced is not clear to a student of mathematical pedagogy. The rôle of the graph in algebra is *to aid in teaching, in learning*, the nature of the solutions and of the roots of simultaneous linear, and quadratic equations, and not at all merely to exhibit another way of looking at the matter, or to add another topic to the subject. The graphical way is the only fairly pedagogical way yet found, to *approach the study* of the nature of the roots and solutions. To lump all graphical considerations into a single, late and isolated chapter, is only to add another extraneous element to the subject of college algebra, which is at best little more than a loose aggregation of such remnants of algebra as are deemed necessary for further mathematical progress, but for which high schools cannot spare time. Such work on the graph would better be left to analytics. The advantage of the isolated treatment is the questionable one of easy omissibility by those who are already skeptical as to its algebraic value.

Aside from these strictures, the treatment of this text is well above the average of those treatments that lean, as does this, to the formal mode of presentation. The different topics are about as well related as they can well be. The difficulties are met by excellent gradations of logical steps and of exercises, and aside from its placing, the graph-

ical work is developed and used excellently. The book is easily more teachable and more educative than the average of even the dozen best college algebras now on the market.

The mechanics of the book, the typography, the paper, the binding and the cover reflect nothing but credit on the makers. The cuts on the graph will be a joy to the teacher and to the pupil. The book is destined to bring additional fame, both as to substance and dress, to the Marsh and Ashton Series, of which it is a part. M.

Physiography. By Rollin D. Salisbury. New York: Henry Holt & Co., 1907. Pp. xx + 770. Maps and illustrations. $3.50.

Teachers of physiography will welcome this new book, not only on account of the large amount of fresh material and the fine illustrations that it contains, but also because it represents the accumulated experience and the method of a scientist whose skill as a teacher is well known and widely appreciated.

The perspective adopted in regard to the treatment of the topics presented furnishes the teacher and the student alike with a standard expression of the material of physiography as taught by American scholars to-day. While the book is largely the result of the author's research, it also represents in large measure the various lines of investigation to which references are made within its pages; and it therefore places the reader in touch, if not always in harmony, with the best that has been written, and may be said to voice the latest and the best thought upon the topics which it treats.

The book goes beyond the elementary treatment found in books of the secondary school. Though the reader is carried forward to a consideration of the unsettled questions that must necessarily arise in any adequate discussion of matters upon which the final word has not yet been said, and though the ripest opinions of the most advanced students are considered in this discussion, still the treatment is in no sense of the word theoretical. In the perspective adopted by the author some teachers may feel that small space has been given to certain topics appropriate to high school, such as rocks and minerals, and to the study of plant and animal geography, but it must be remembered that in colleges, where the author designs the book to be used, special courses in these related topics are given in the associated departments. And, further, space enough could not be given in a text on physiography for a discussion adequate to the needs of the teacher or the advanced student of these lines that are only indirectly represented in the subject. In fact a strong point in the book is this, that, with the exception of a few references to physiographic effects on human life, scattered through its pages, it presents physiography as a science associating causes and effects clearly and forcibly, thus avoiding the mistake made by many authors who try to exalt physiographic control at the expense of a science deeply interesting for its own sake.

The author holds persistently to that idea of physiography which regards the origin of land forms as its chief problem; or, as is expressed in the introduction, the scope of the subject includes those facts that pertain to the plane of contact of the air and water with the land, and

of air with water. The results of the activity of physical forces through these three media, air, water, and land, by the very nature of things can be expressed only in terms of the land, since air is constantly changng its form and thus assumes a relief temporarily, only, while both air and water leave more or less permanent forms in the surface of the earth. But any study of the origin of land forms involves the study of both the air and the water, since the former becomes the medium through which natural forces operate, while the latter is the greatest agent in producing the effects. Though the major part of the text is given to land forms, still 273 pages remain for the treatment of the atmosphere, the ocean, and the earth's solar relations. The treatment is essentially dynamic and the movement in the direction of the explanation of the origin of the land forms of the earth. The reader is led to see these forms in the process of becoming what they are, and to anticipate the time when they shall give way to other forms. The surface of the earth becomes a stage where physical forces play their part, now in one role, now in another, until the land above the sea is reduced to base level or rejuvenated to pass again through a similar sequence of events.

The first chapter of the book introduces the reader to the chief relief forms of the crust of the earth and to the material out of which they are formed. This general survey places the problem of the land forms well before the student and prepares him for the consideration in the following eight chapters of the agents that have shaped them. The discussion runs on smoothly in the explanation of the work of the atmosphere, of ground water, running water, snow and ice, of waves and currents in the construction of shore forms, of vulcanism, and the effects of crustal movement, or diastrophism. These chapters are followed by a very excellent generalization and summary of the origin and distribution of land forms.

The part played by the atmosphere in the evolution of relief gains for it a treatment comparable, in detail, to that presented by special texts on meteorology. Here, again, the sequence is dynamic. The energy received from the sun is followed through a series of transformations, in the chapters on atmospheric pressure, the movement of air currents, and the transportation of water vapor to its final precipitation upon the earth. The various elements of climate and the zones of climate receive due attention. In these chapters the composition of the atmosphere, the air in its life relations, the distribution of temperatures over the earth, and the philosophy of air movement are treated in an interesting and original manner. The chapter on the storms of the United States is especially detailed and illustrated by a complete seres of isothermal charts and weather maps. Following the chapters on the atmosphere, six chapters, covering fifty pages, are given to the discussion of the principal facts of oceanography.

The text contains more than seven hundred illustrations, forty-three of which are sections of topographic maps, and of the others more than three hundred are beautiful half-tones. The placing of pictures with respect to text is admirable. One can turn to any of the illustrations

and find adjacent to it the statement that explains it, so that illustration and text seem to blend in conveying the idea to the reader. The halftones are not merely inserted, as in some books, but bear a vital relation to the text.

At the end of each chapter one finds a well selected list of topographic maps, with suggestions as to their use, in relation to the text, and a list of classified and paged references for supplementary reading. These references, even without the text, would be a most valuable aid to the advanced student or teacher, since they represent the cream of the exercises and assigments accumulated by long experience in the class room. The style of the author, in the exposition of the science, is delightfully clear, and the concise statement of the most abstruse parts of the work will be a source of satisfaction to every student who appreciates exactness and definiteness. Though the book is written for college students, the style is so clear, and the treatment so straightforward, that the average high school student will read it as easily as the more elementary texts.

I have used the book with classes in the normal school and find it well adapted to the work of introducing the student to the more general field of geography. The students tell me that they find the text clear and interesting. They certainly get a good grip upon the subject as shown by their recitations.

No advanced student or teacher of geography can afford to do without this comprehensive statement of the principles and matter of physiography.

L. H. Wood.

State Normal School, Kalamazoo, Mich.

THERE ARE NO ISSUES OF THIS JOURNAL FOR JULY, AUGUST AND SEPTEMBER.